MOUT FACT Proposal Three

Rapid Generation of Synthetic Urban Environments

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MOUT FACT Project Implementation Meeting, May 14-15

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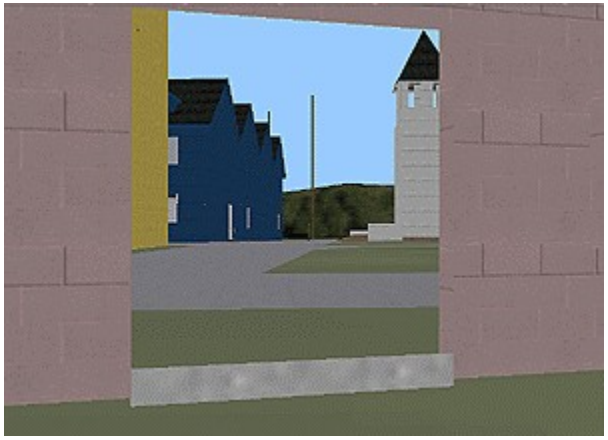
Traditional “MOUT” Database

Overview of Ft. Benning MOUT site

Ground view of MOUT site buildings



View from building entranceway

Windows and entrances for multiple buildings

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Complex GeoSpecific Urban Environments

Philadelphia skyline with landmark models

Automatically generated road intersections and lane markings

Telephone pole and traffic barrel placement in Schenley Park

Urban Clutter: ATMs, newspaper boxes, mail boxes, and trash cans

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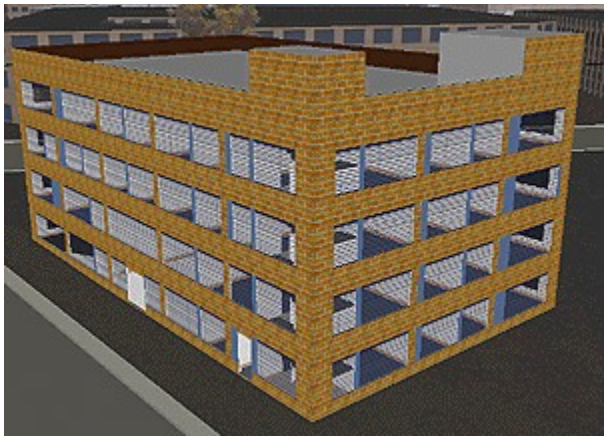
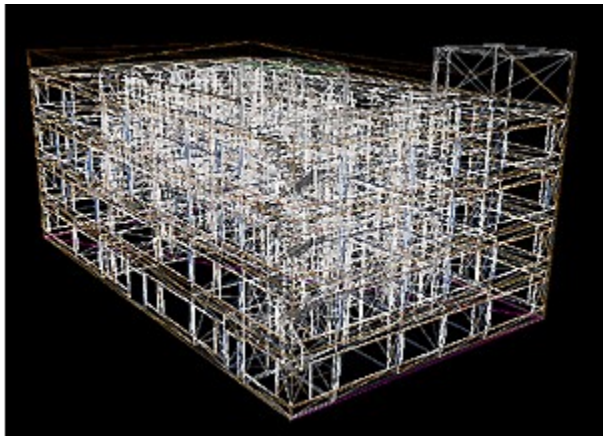
Toward Complex 3D Building Generation

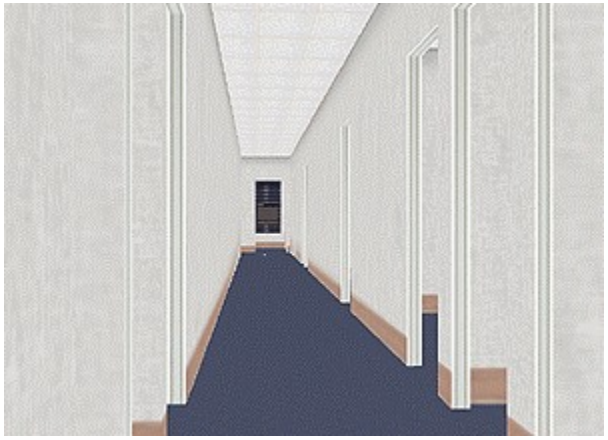


Multi-story office building



Geometry of building model

Exit stairwell, doorway, and window



Interior hallway with office entrances

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Rapid Generation of Synthetic Urban Environments

- **Task Descriptions and Participants**
- **Overview of existing and emerging technology for urban database construction**
- **Why use validated models (spatial organization / construction practices) to control urban model generation?**
- **Current capabilities and MOUT FACT contributions**

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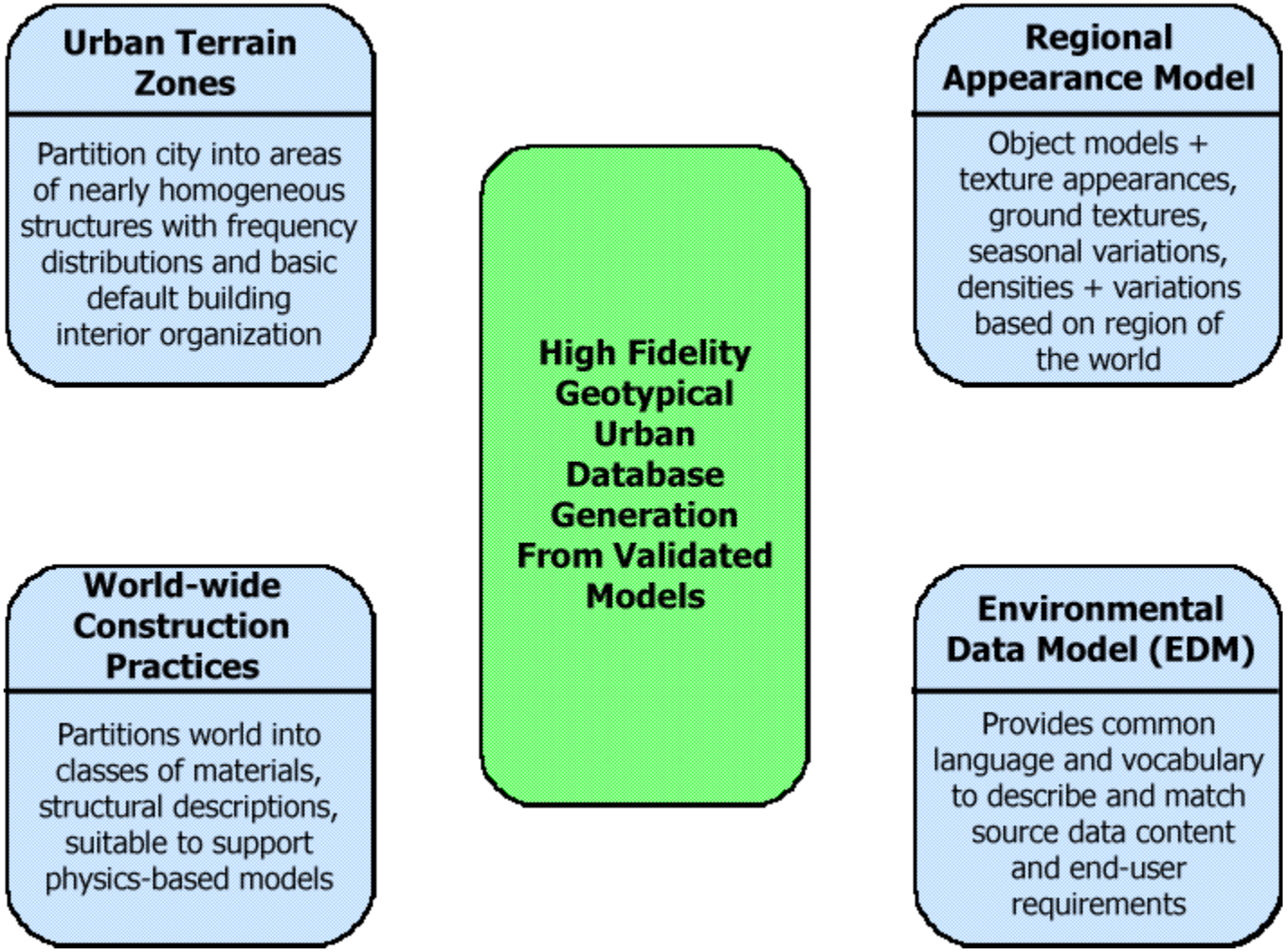
Automated Geotypical Urban Database Generation


Urban Terrain Zones
Partition city into areas of nearly homogeneous structures with frequency distributions and basic default building interior organization
Regional Appearance Model
Object models + texture appearances, ground textures, seasonal variations, densities + variations based on region of the world
High Fidelity Geotypical Urban Database Generation From Validated Models
World-wide Construction Practices
Partitions world into classes of materials, structural descriptions, suitable to support physics-based models
Environmental Data Model (EDM)
Provides common language and vocabulary to describe and match source data content and end-user requirements

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Year One Project Tasks

- **Task 1:** Build JRTC MOUT DB for OOS MOUT developers
- **Task 2:** Build geotypical UTZ for three representative (worldwide) areas
- **Task 3:** Build geospecific UTZ for three representative areas
- **Task 4a:** Initial MES support for UTZ building interiors
- **Task 5a:** Initial geospecific building interiors from CAD

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Year Two Project Tasks

- **Task 4b:** Advanced MES support for UTZ building interiors
- **Task 5b:** Advanced geospecific building interiors from CAD
- **Task 6:** Initial generation of geospecific underground models
- **Task 7:** Develop representation for underground models in OOS/SEDRIS
- **Task 8:** Integration and connectivity between buildings and underground models

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Project Interactions and Participants

- **PEOSTRI / OOS** Process validation, feedback, OOS validation
- **AMSAA** Urban Terrain Zone model generation
- **ERDC-WES** WorldWide Construction Practices
- **ERCD-TEC** EDBIPT and technology validation
- **TerraSim** Technology development and delivery

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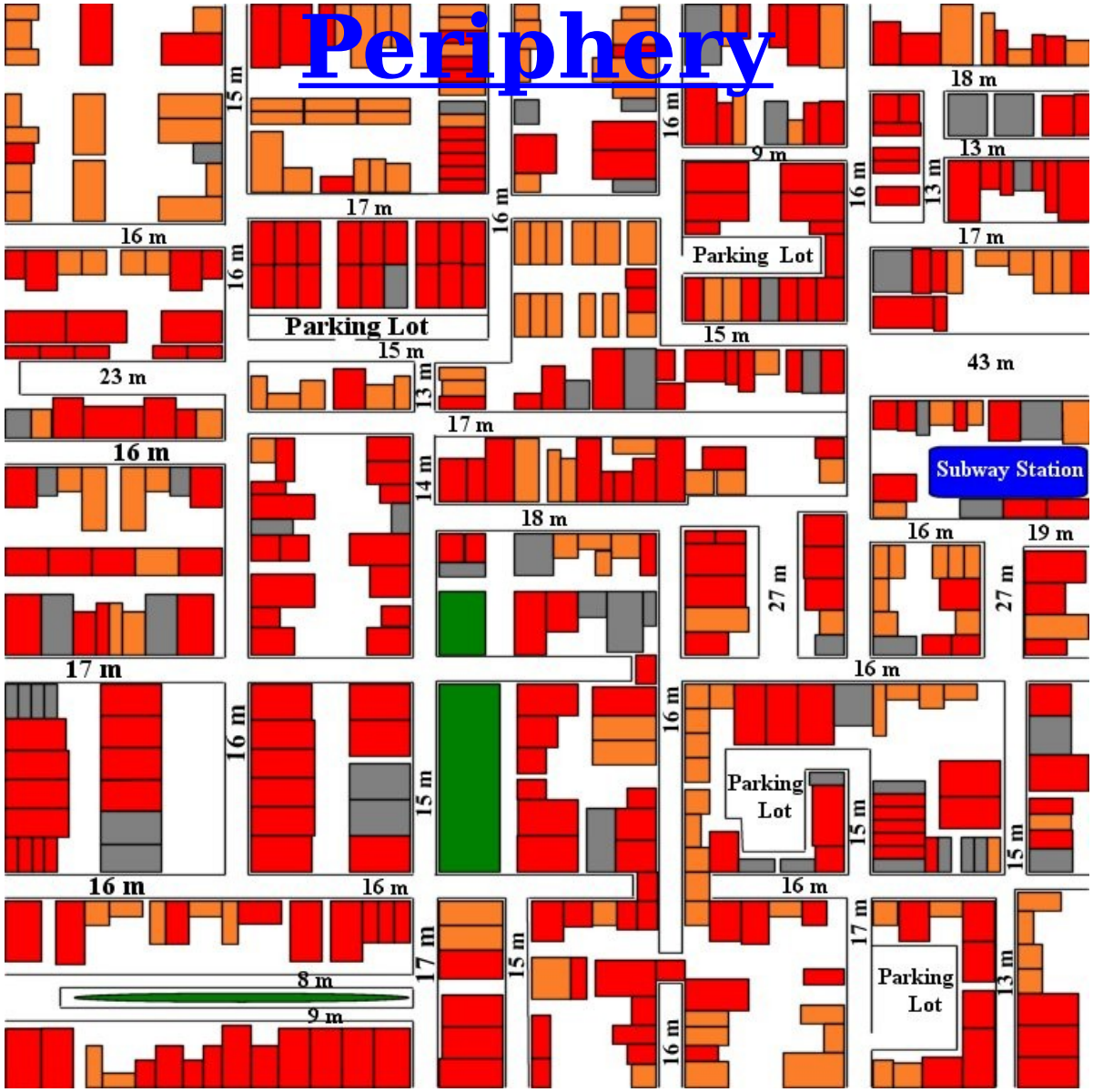
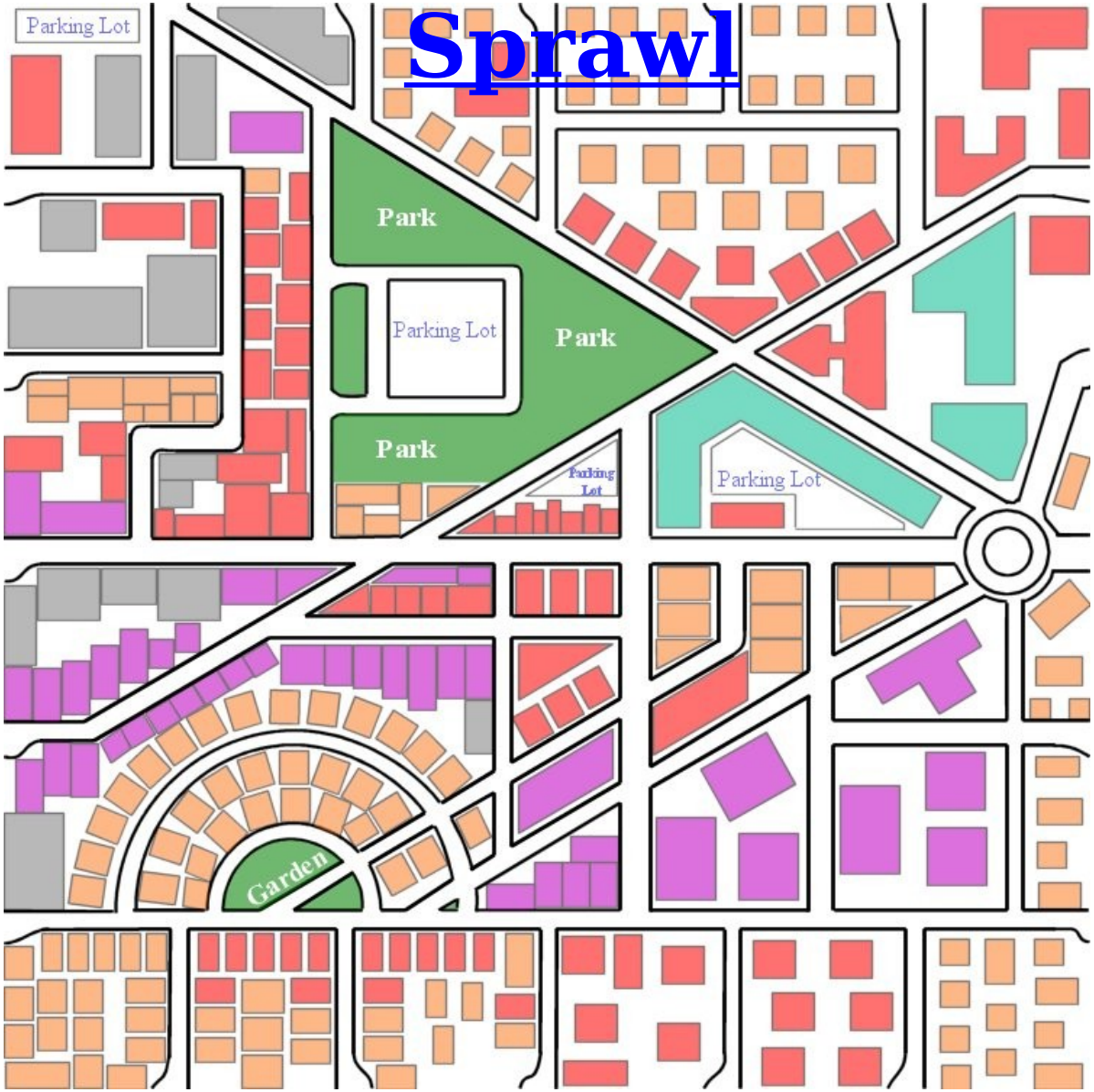
Why Use Validated Models for Urban Generation?

- **Geotypical generation needs to be grounded in several ways**
  - Distribution of urban features, density and spatial organization, presence
  - Construction practices to support building interior and attribution
    - Support BDA, CGF, and other real-time models
  - Appearance of models and variations for visual applications
  - Ability to talk about actual source data content
    - Check that available source data satisfies exercise requirements
    - Fill in or infer missing information using community agreed process
- **Geospecific generation needs to be grounded as well**
  - But available CAD or GIS model rarely have information beyond geometry
  - GIS source is other at the wrong resolution (too coarse)
    - Requires refinement constrainted by existing data
    - Not unlike the basic UTZ to environment problem

Expanded Small City Periphery

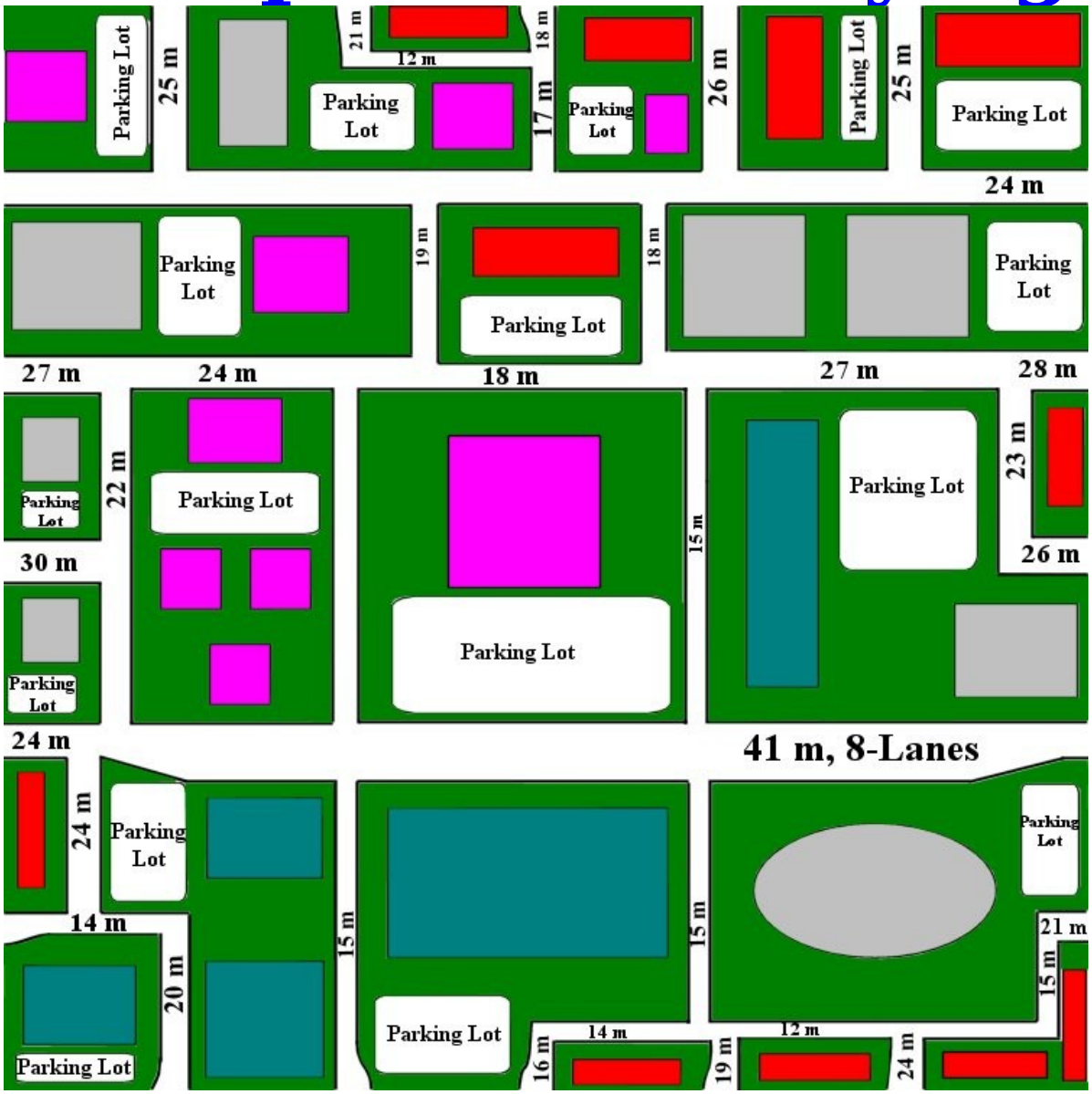


Expanded Residential Sprawl



- Wood Frame
- Mass Construction Brick or Masonry
- Mass Construction Stone
- Mass Construction Concrete
- Mass Construction Brick/Stone
- Landscaped

Expanded Outlying High



All buildings have steel frames

- Brick and Glass Cladding
- Glass and Steel Cladding
- Concrete, Brick and Glass Cladding
- Concrete and Glass Cladding
- Landscaped

Expanded Commercial/Industrial/Commercial Ribbon

- Wood Frame
- Brick mass const.
- Concrete Block
- Concrete Tilt-Up
- Stone mass const.

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Commercial Ribbon Excel Spreadsheet

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	A	B	C	D	E	F	G	H	I	J	K
1	Commercial/Commercial Ribbon/										
2	121										
3	Building #	(x,y lower left corner)		(x,y lower right corner		(x,y upper right corne		(x,y upper left corner)		(Number	stories, material)
4	1	0	45	46	45	46	1	0	1	2	Concrete Block
5	2	58	87	86	87	86	1	58	1	1	Concrete Block
6	3	61	107	92	107	92	94	61	94	1	Wood Frame
7	4	137	51	222	51	222	5	137	5	2	Concrete Block
8	5	134	120	158	120	158	61	134	61	1	Wood Frame
9	6	188	112	221	112	221	72	188	72	1	Concrete Block
10	7	270	61	344	61	344	0	270	0	2	Corrugated Steel Wall
11	8	295	115	356	115	356	93	295	93	2	Wood Frame
12	9	385	118	406	118	406	69	385	69	1	Concrete Block
13	10	389	35	479	35	479	0	389	0	2	Wood Frame
14	11	444	236	474	236	474	72	444	72	2	Brick
15	12	522	62	576	62	576	2	522	2	2	Tilt-up Concrete
16	13	515	85	543	85	543	66	515	66	1	Brick
17	14	544	143	558	134	545	113	530	122	2	Wood Frame
18	15	581	110	605	96	596	81	572	96	3	Tilt-up Concrete
19	16	609	102	622	94	608	73	596	81	3	Tilt-up Concrete
20	17	571	186	586	177	572	155	557	164	2	Wood Frame
21	18	607	164	649	138	639	122	598	148	2	Tilt-up Concrete
22	19	610	249	625	240	606	208	590	218	3	Tilt-up Concrete
23	20	643	81	671	64	658	42	630	60	2	Tilt-up Concrete
24	21	670	124	698	107	684	85	656	102	3	Tilt-up Concrete

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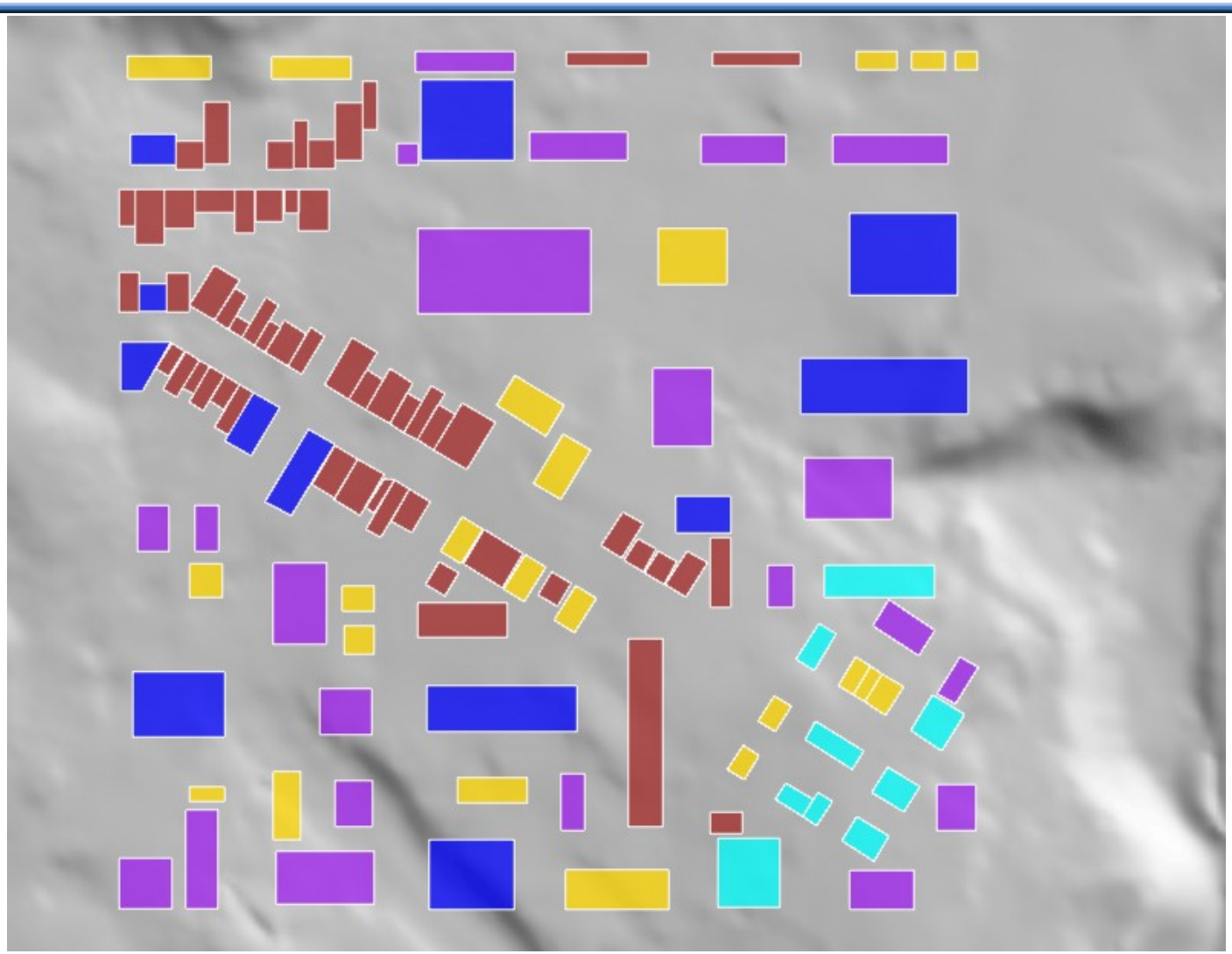
Commercial Ribbon Converted to GIS File



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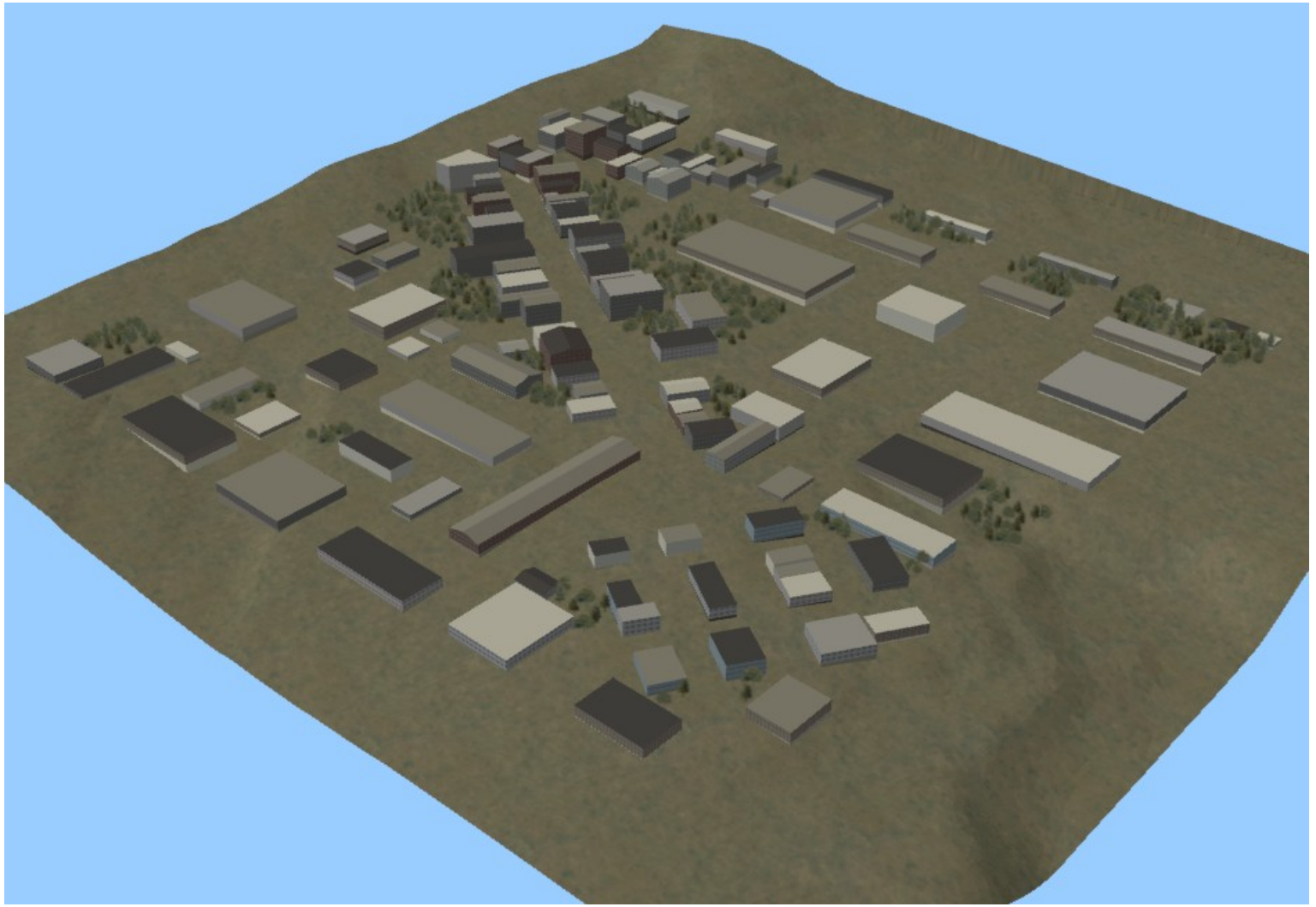
Commercial Ribbon Visualization Overview



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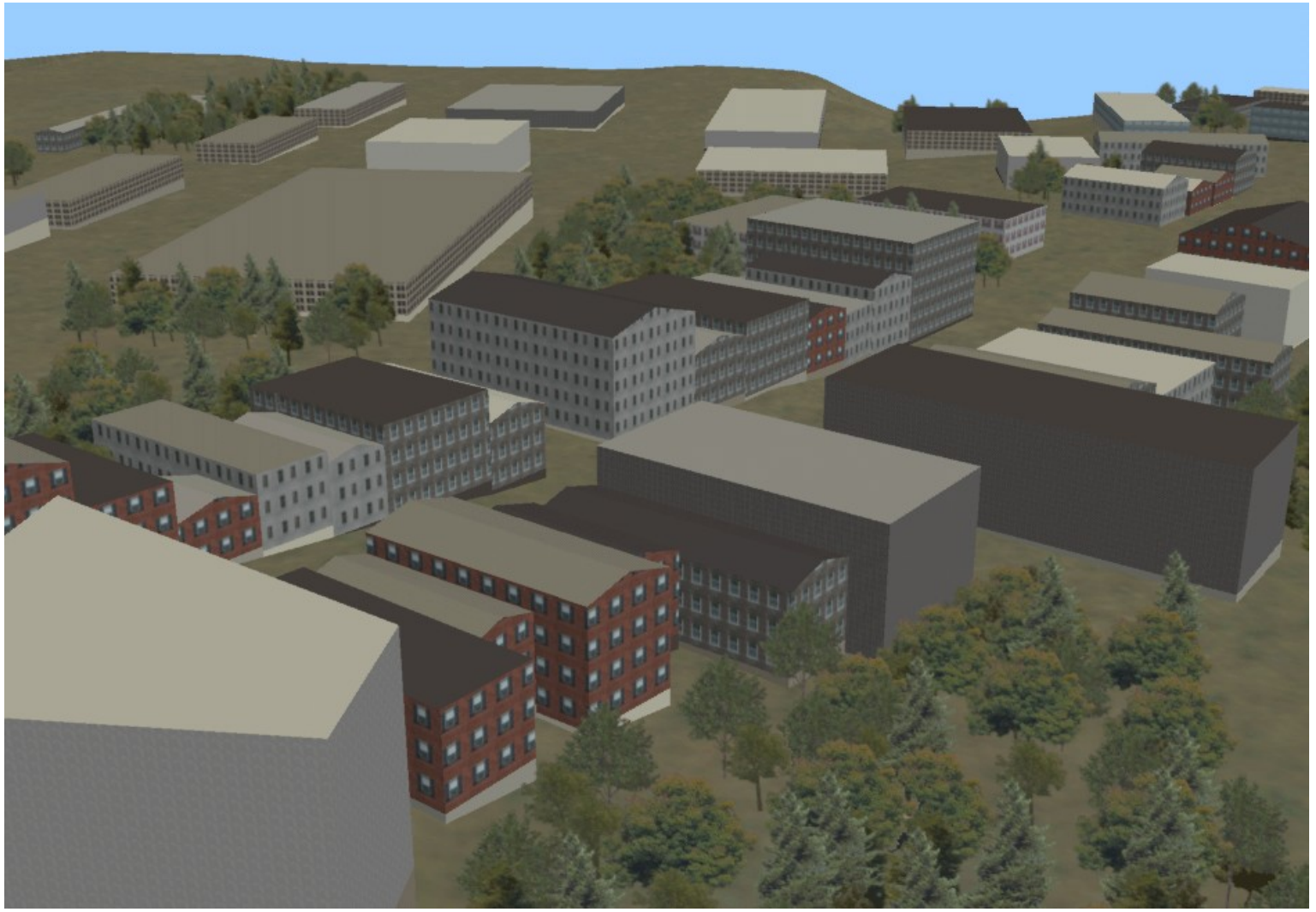
Commercial Ribbon Visualization Close-up



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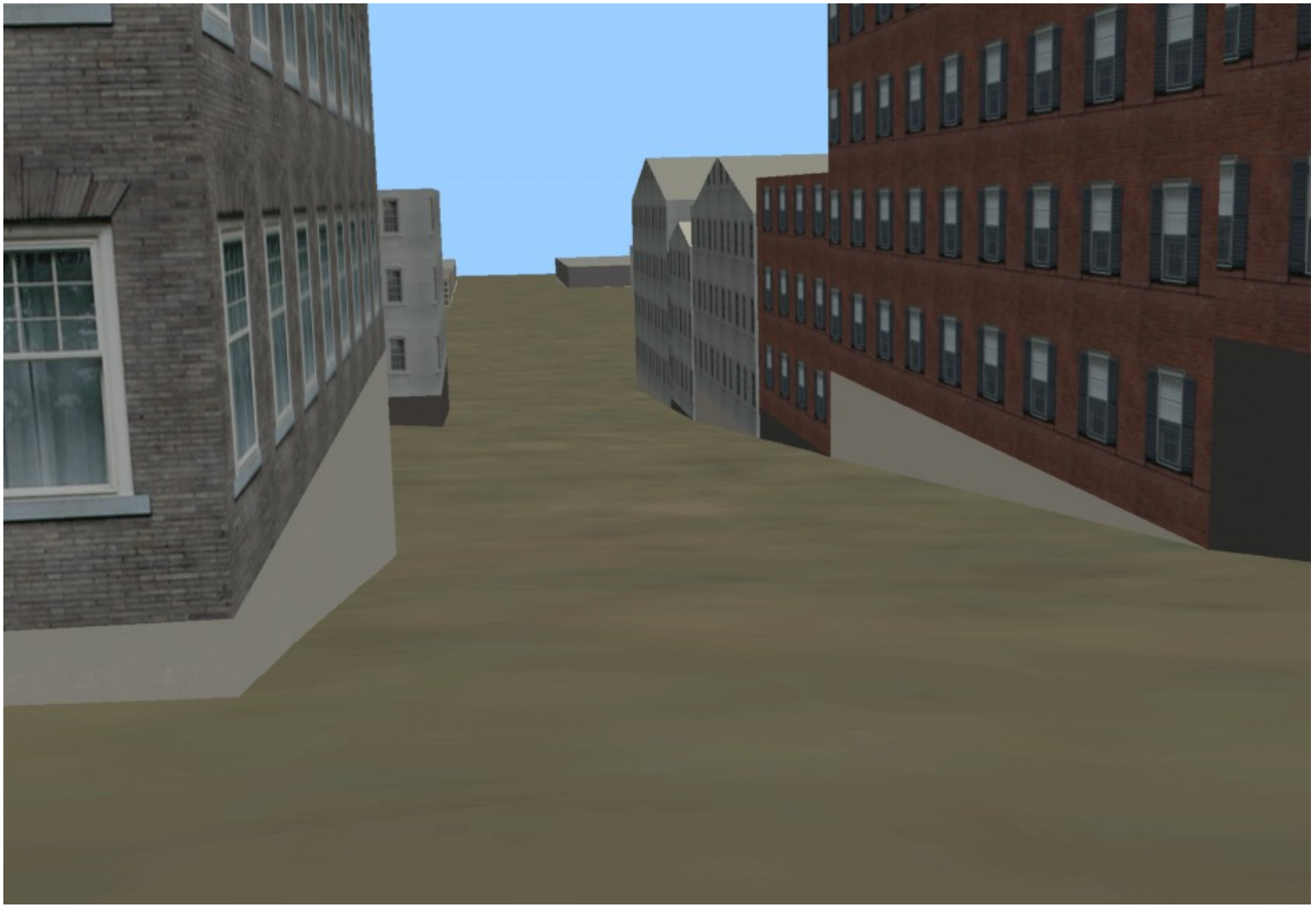
Commercial Ribbon Visualization Close-up



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Commercial Ribbon Visualization Close-up

TerraSim

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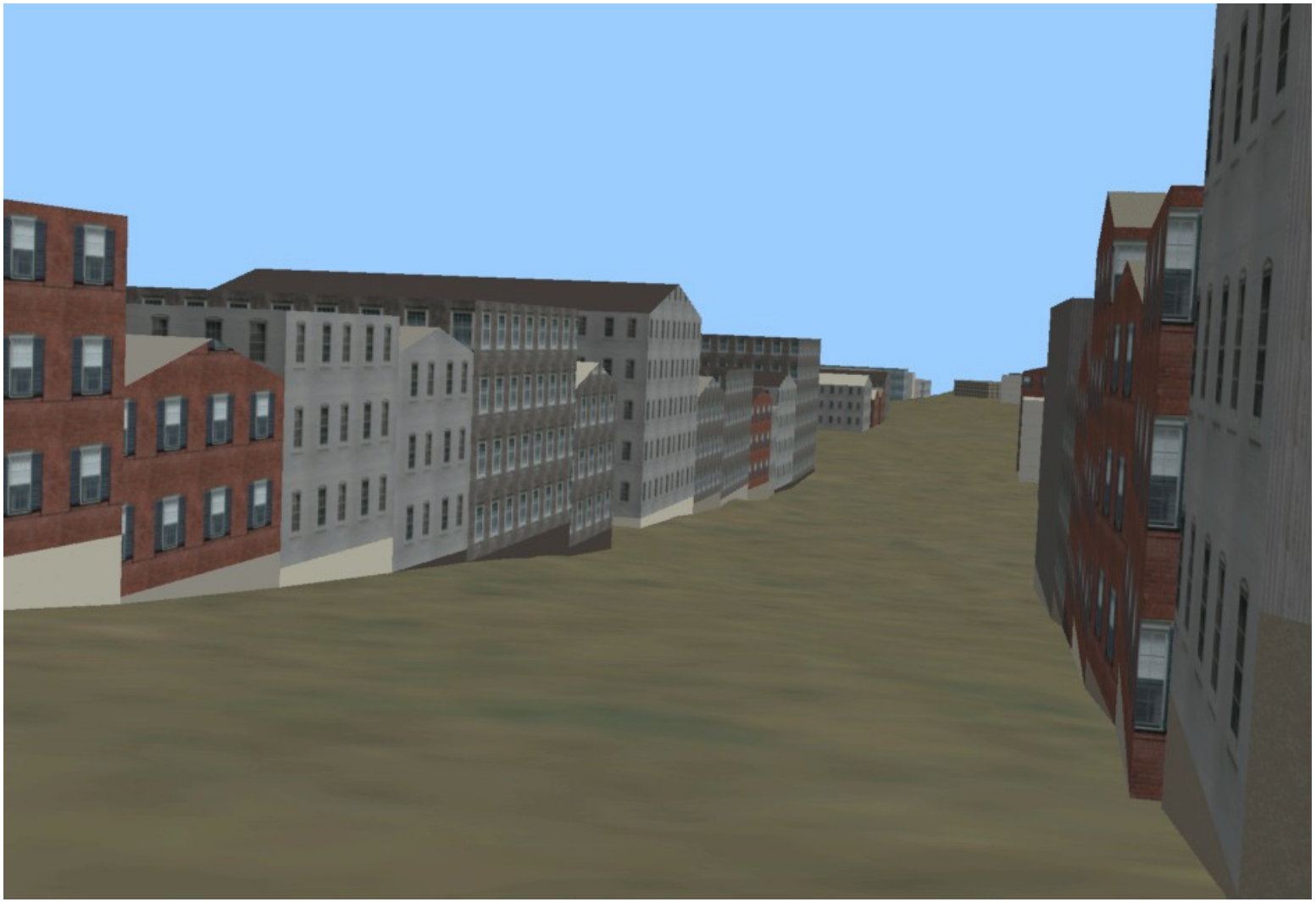
Commercial Ribbon Visualization Close-up



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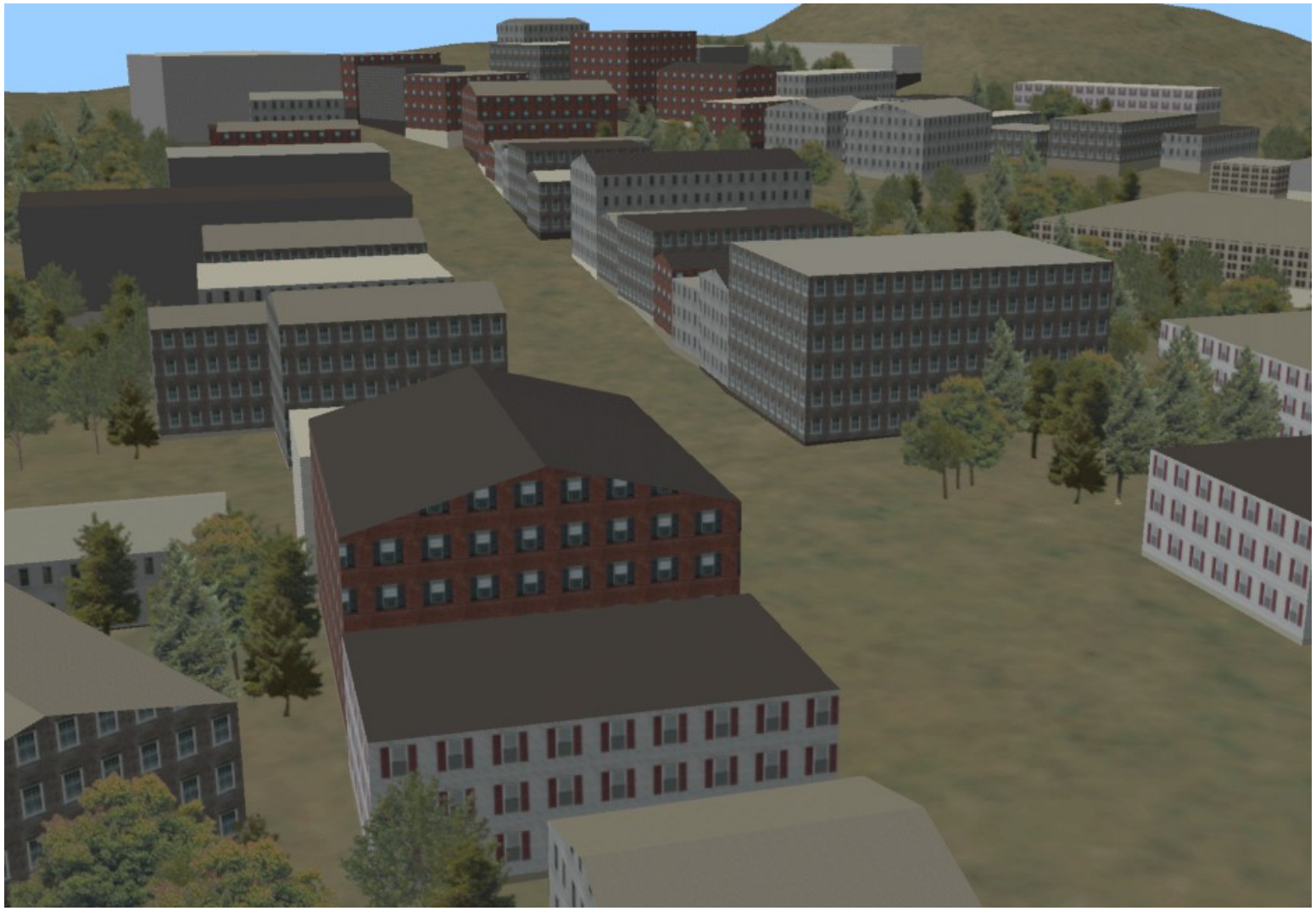
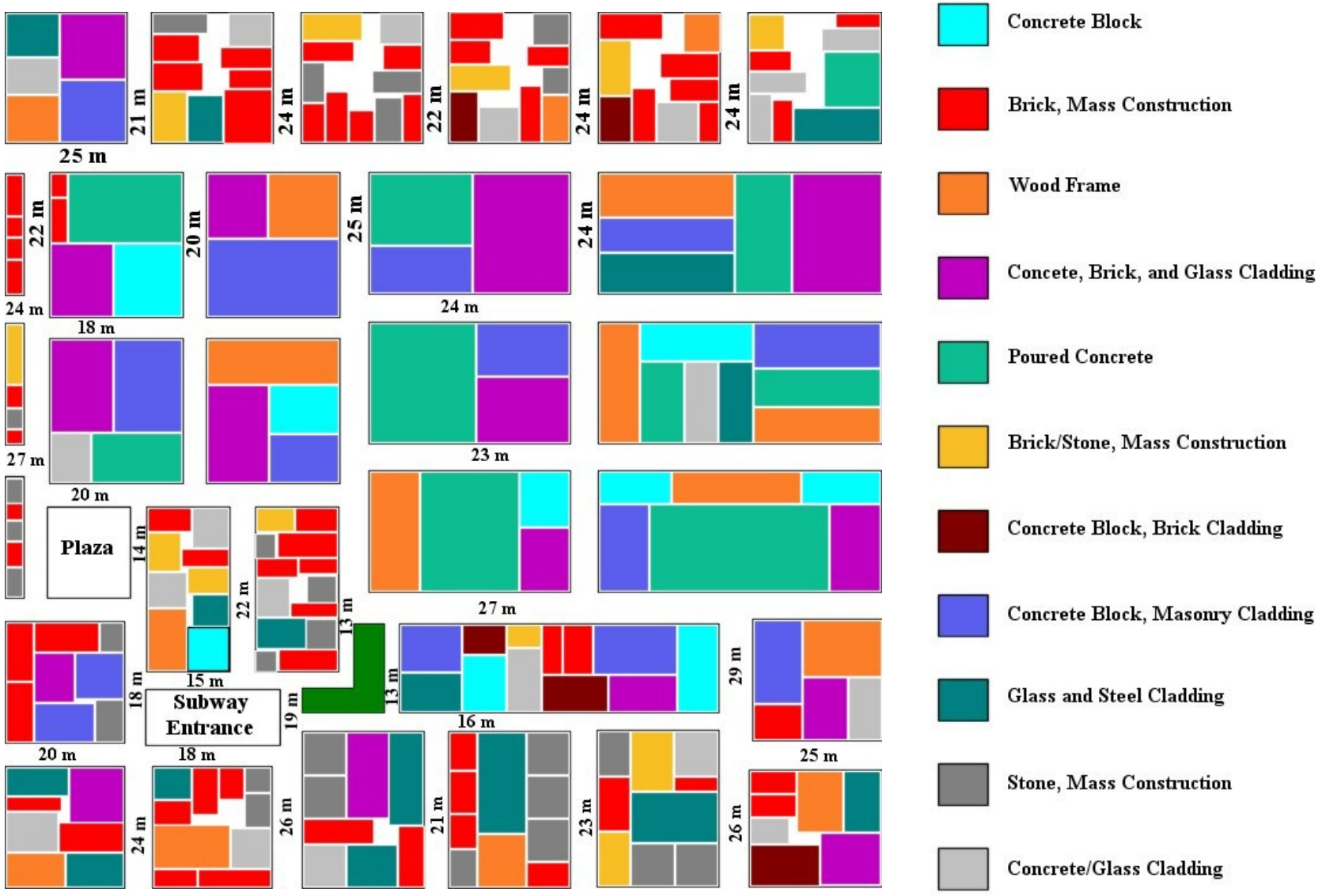


Expanded City Core



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City Core Excel Spreadsheet

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	City Core	All data in Meters unless otherwise stated.												
2	One story = 12 feet													
3	208 Buildings													
4	750 m x 750 m template													
5	Building Numbe	x1	y1	x2	y2	x3	y3	x4	y4	Building Height (Stories)	Wall Composition			
6	1	1	38	1	1	47	1	47	38	8	Glass & Steel Cladding, Steel Frame			
7	2	47	57	47	1	103	1	103	57	6	Concrete, Brick & Glass Cladding, Steel F			
8	3	1	71	1	38	47	38	47	71	8	Concrete & Glass Cladding, Steel Frame			
9	4	1	111	1	71	47	71	47	111	3	Wood Frame/Cladding			
10	5	47	111	47	57	103	57	103	111	3	Concrete Block & Masonry Cladding, Ste			
11	6	126	19	126	1	173	1	173	19	4	Stone, Mass Construction			
12	7	191	30	191	1	228	1	228	30	3	Concrete & Glass Cladding, Steel Frame			
13	8	126	43	126	19	166	19	166	43	5	Brick, Mass Construction			
14	9	184	48	184	30	228	30	228	48	5	Brick, Mass Construction			
15	10	126	68	126	43	169	43	169	68	6	Brick, Mass Construction			
16	11	191	66	191	48	228	48	228	66	6	Brick, Mass Construction			
17	12	126	111	126	68	155	68	155	111	4	Brick & Stone, Mass Construction			
18	13	155	111	155	71	187	71	187	111	4	Glass & Steel Cladding, Steel Frame			
19	14	187	112	187	66	228	66	228	112	4	Brick, Mass Construction			
20	15	254	24	254	1	305	1	305	24	5	Brick & Stone, Mass Construction			
21	16	320	27	320	1	356	1	356	27	4	Concrete & Glass Cladding, Steel Frame			
22	17	254	42	254	24	298	24	298	42	6	Brick, Mass Construction			
23	18	323	49	323	27	356	27	356	49	6	Brick, Mass Construction			
24	19	254	78	254	42	274	42	274	78	5	Stone, Mass Construction			
25	20	314	69	314	49	356	49	356	69	5	Stone, Mass Construction			
26	21	254	111	254	78	274	78	274	111	5	Brick, Mass Construction			
27	22	274	111	274	68	294	68	294	111	6	Brick, Mass Construction			
28	23	294	111	294	84	316	84	316	111	5	Brick, Mass Construction			
29	24	316	111	316	73	339	73	339	111	5	Stone, Mass Construction			
30	25	339	111	339	69	356	69	356	111	6	Brick, Mass Construction			
31	26	380	24	380	1	426	1	426	23	6	Brick, Mass Construction			
32	27	451	28	451	1	482	1	482	28	5	Stone, Mass Construction			
33	28	380	45	380	24	415	24	415	45	5	Brick, Mass Construction			

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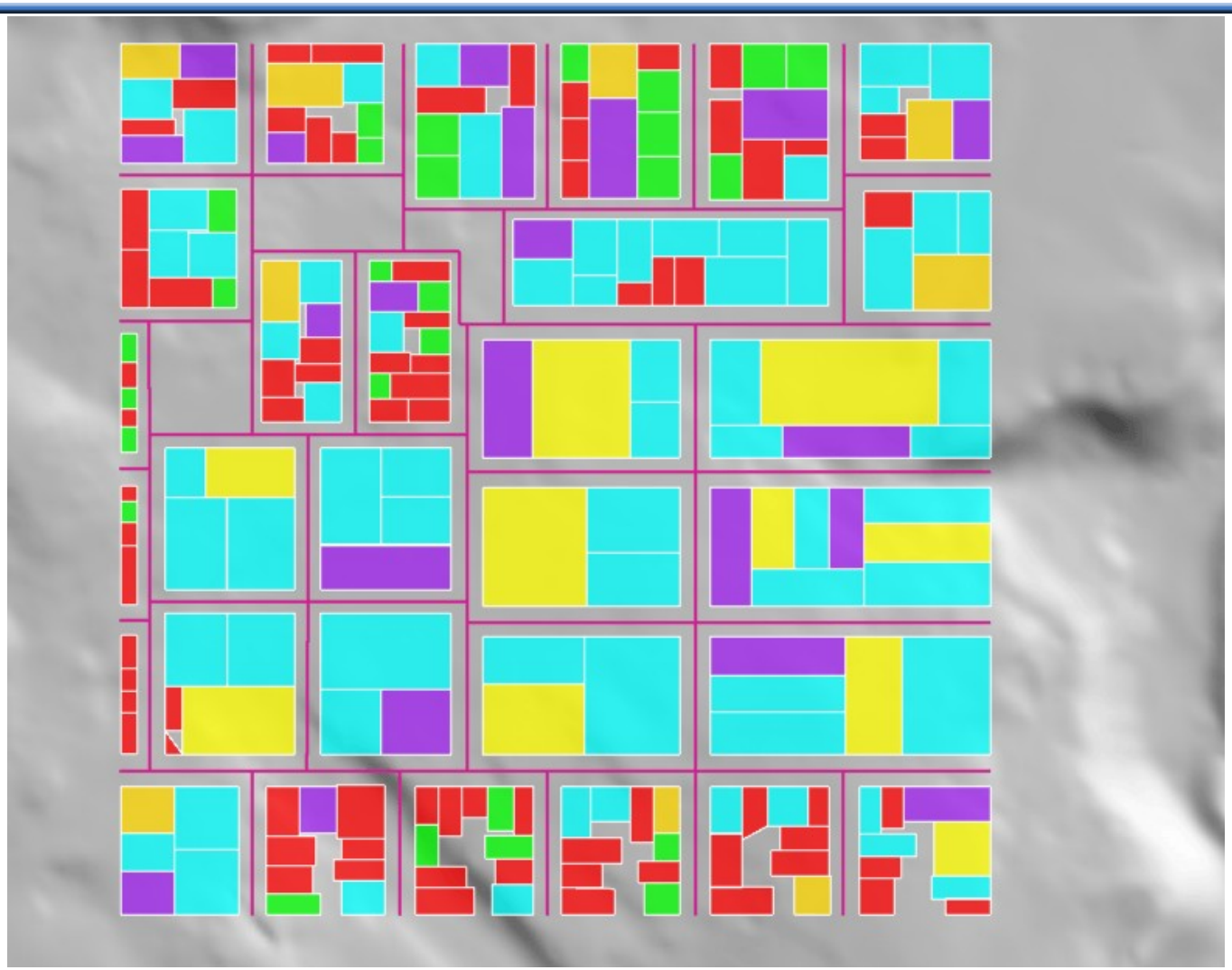
City Core Converted to GIS File



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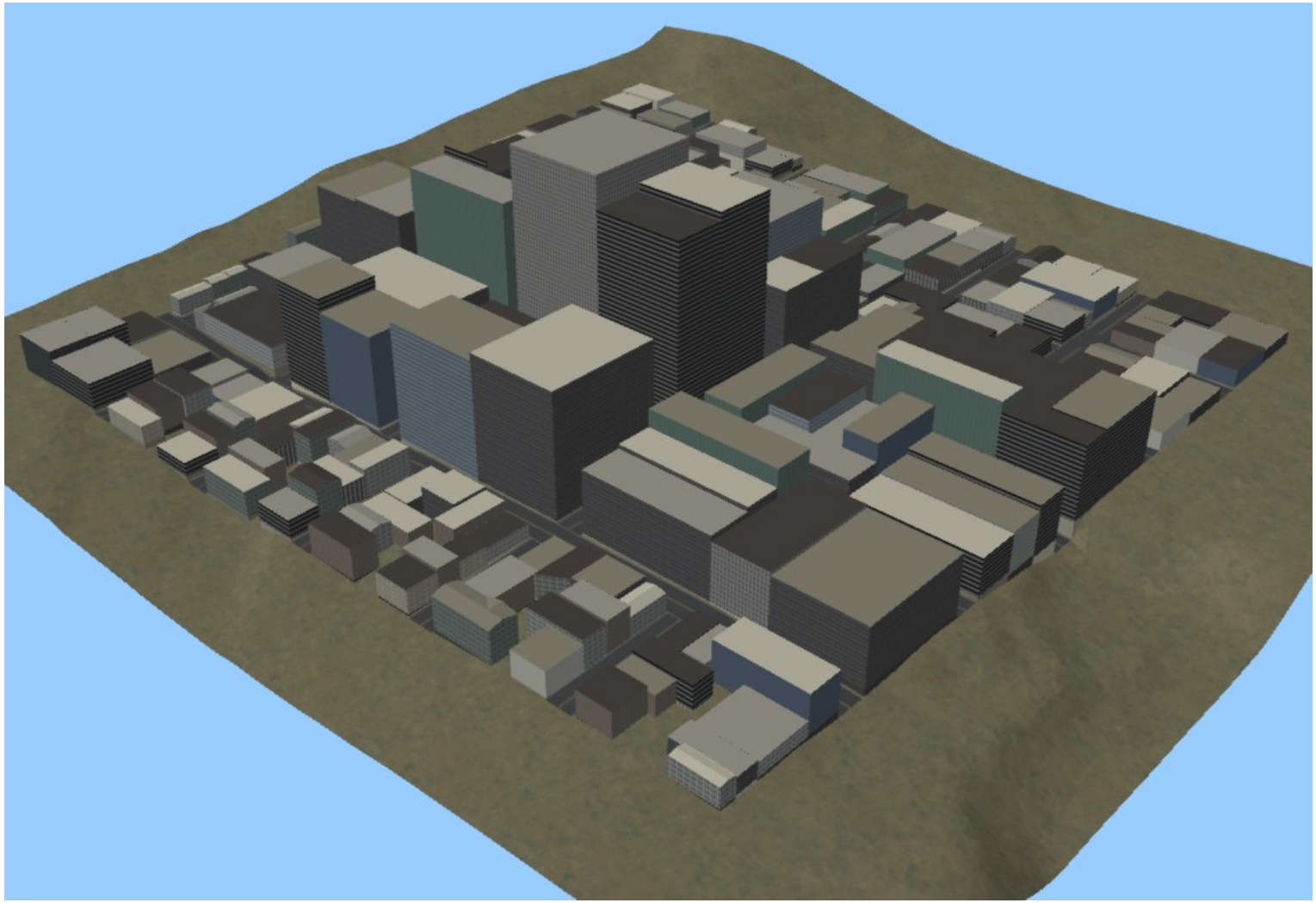
City Core Visualization Overview



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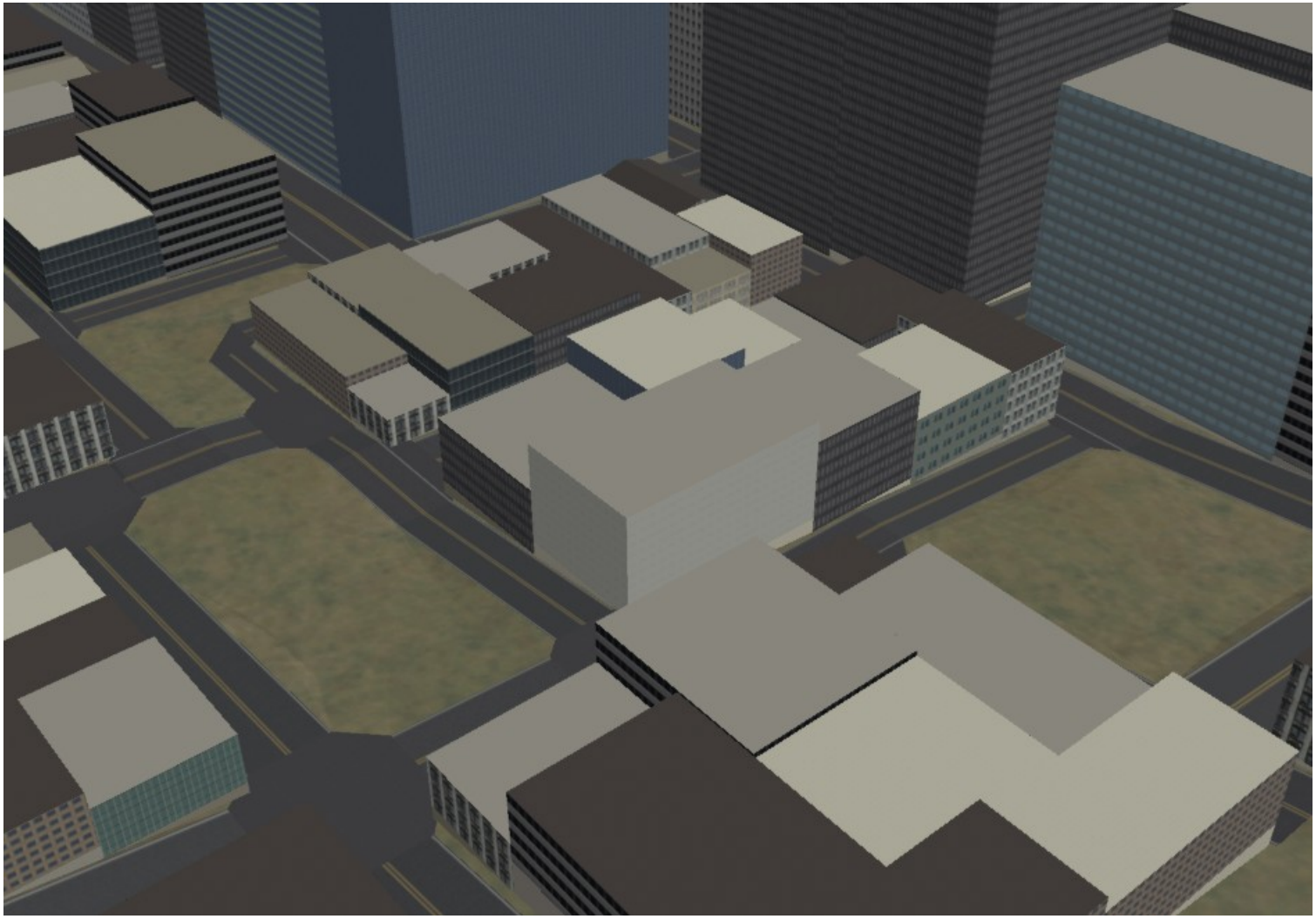
City Core Visualization Close-up



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City Core Visualization Close-up

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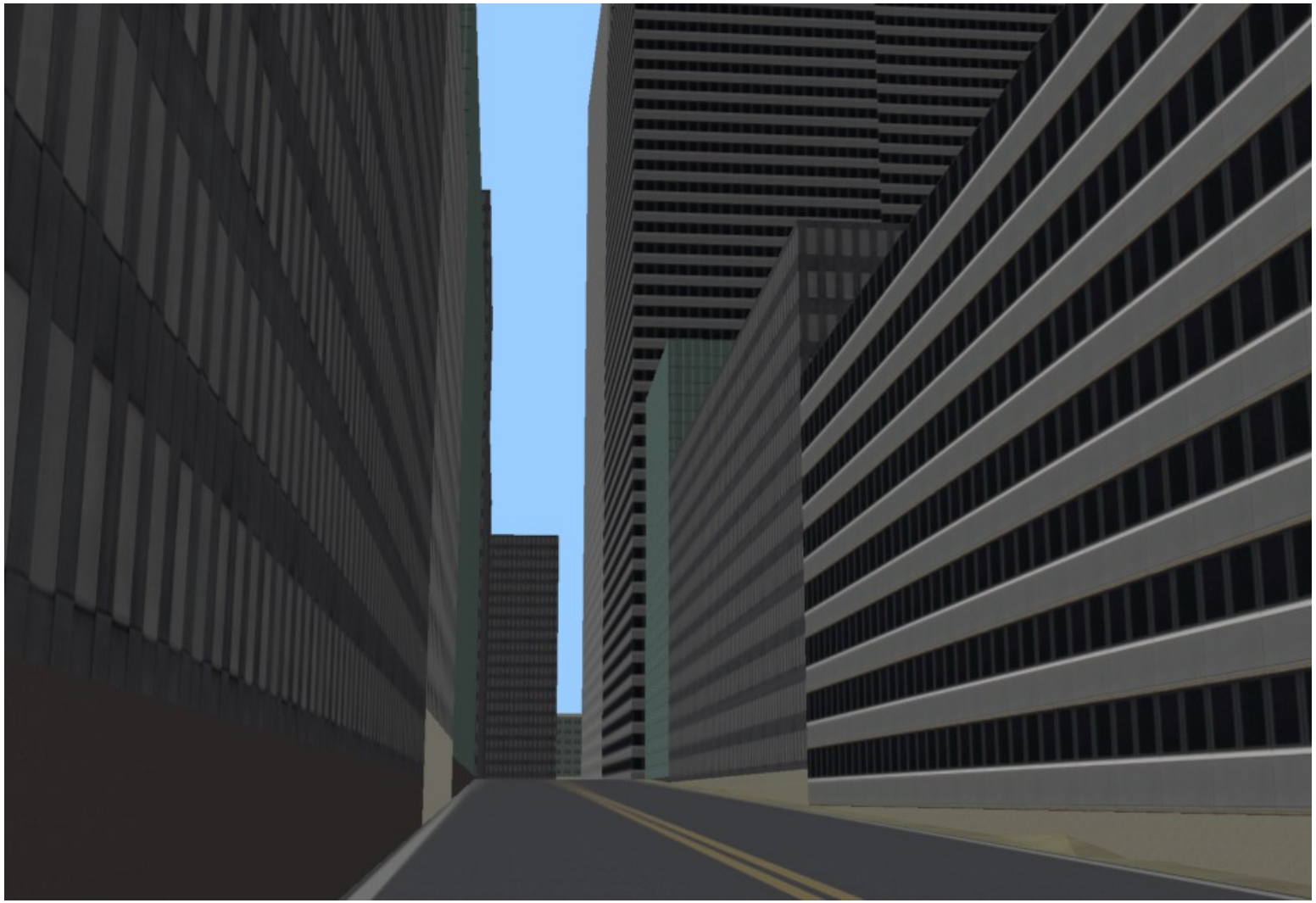

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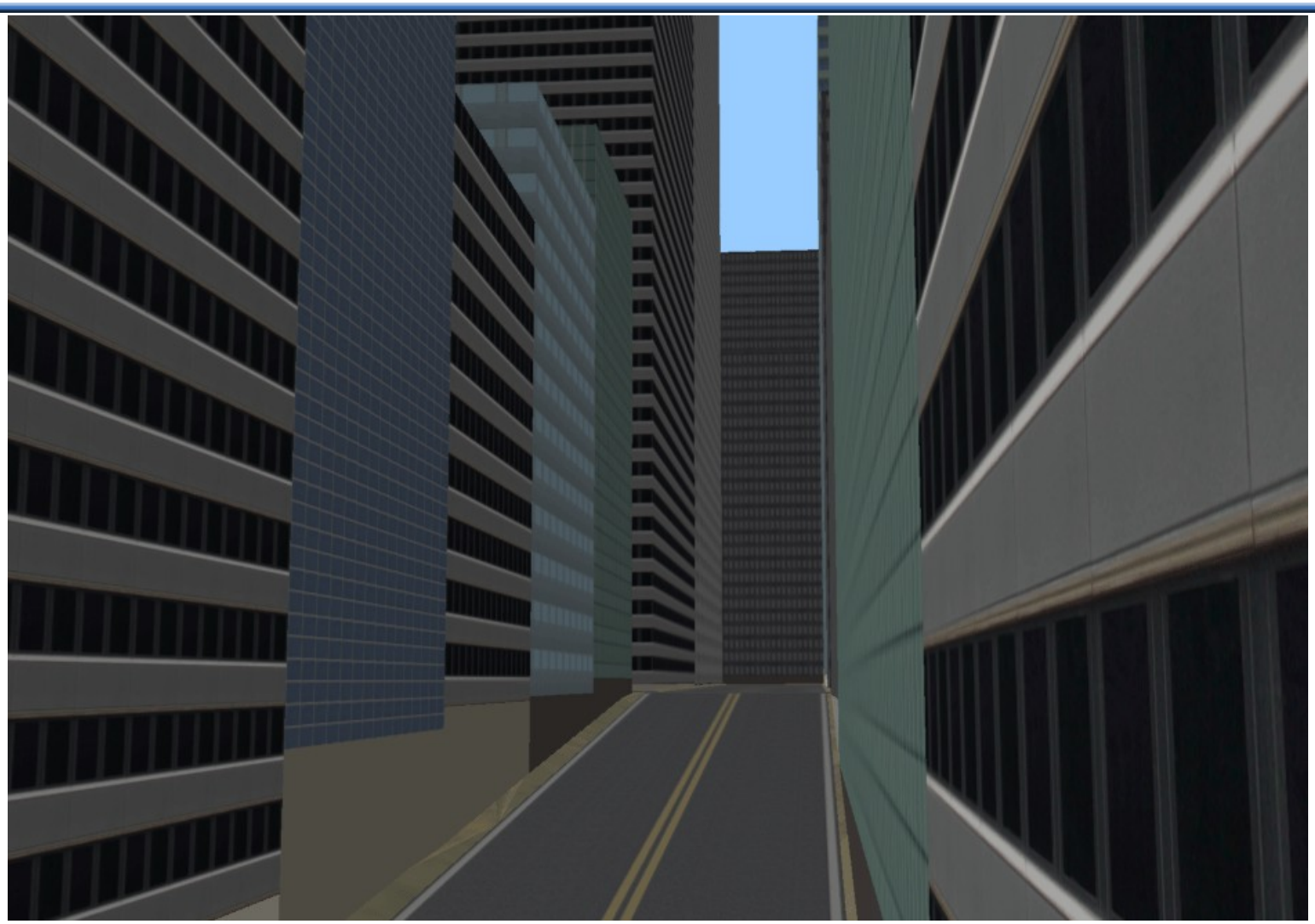
City Core Visualization Close-up



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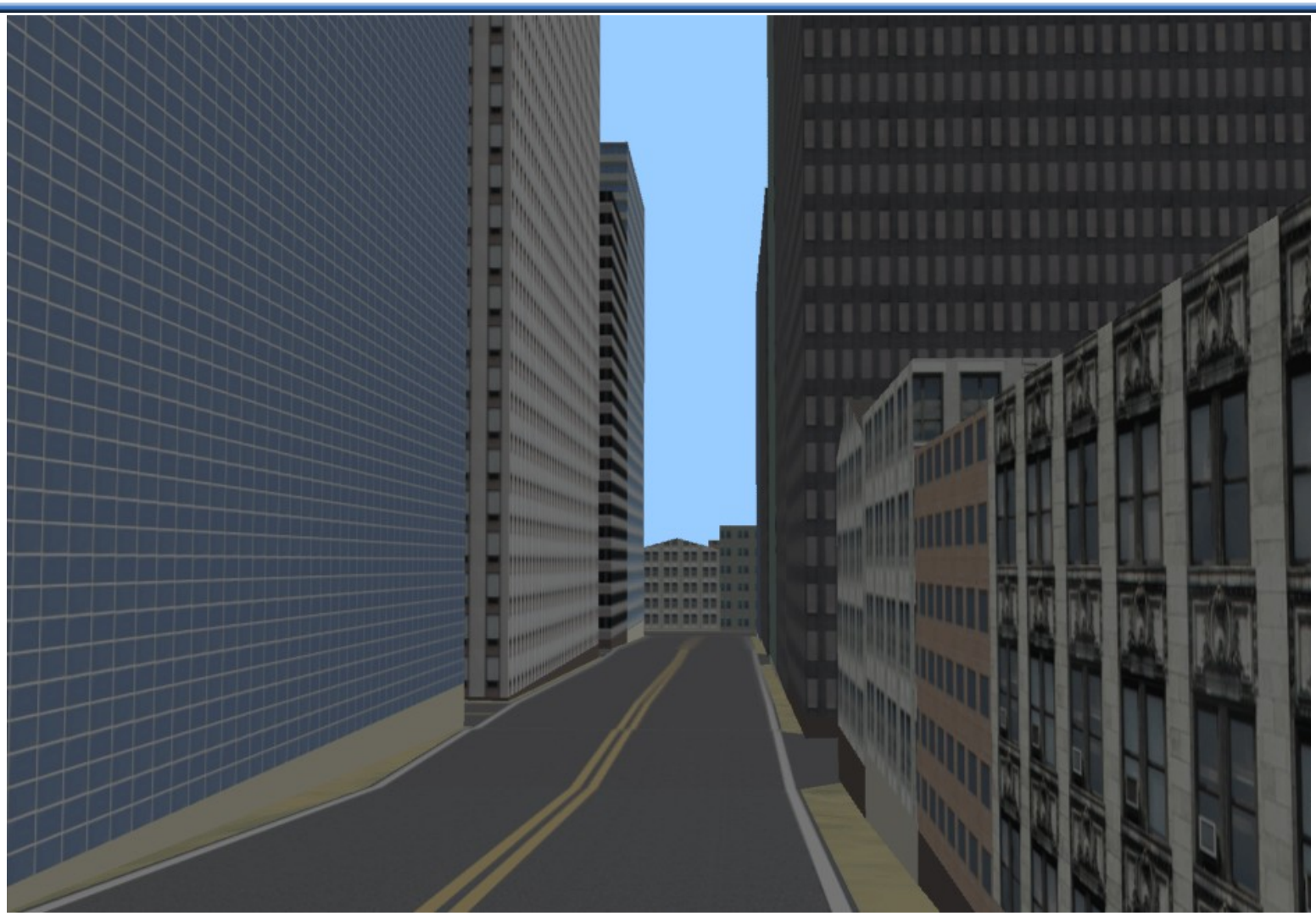

TerraSim

Previous Capabilities for Interior Generation

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- **Funding from TerraSim IR&D, Army Phase II SBIR, PEOSTRI SNE/STO**
- **Two generation methods developed**
  - Space filling algorithm generates rooms/halls/stairs to GIS footprint
    - Supports multiple levels of the same plan
    - Highly flexible template based descriptions
  - CAD data to constrain space filling algorithm to generate geospecific interior
- **Both methods interact with:**
  - Room clutter generator (desks, chairs, computer
  - Hall clutter generator (lights, electrical outlets, ceiling)
- **Export geometry to SEDRIS and OpenFlight**
- **Single building at a time**

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Building Interior Data Sources

- **Building interiors are designed so that they can be created using textual attribution in place of geometry**
- **Customization of interiors is controlled via attributes**
- **Templates can define geotypical building interiors**
- **Attribution can range from:**
  - Minimal attribution - footprint and building height
  - Moderate attribution - floorplans with feature descriptions, placement of interior objects
  - Maximum attribution - structural constraints, and utility schematic

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Building Interior Data Sources

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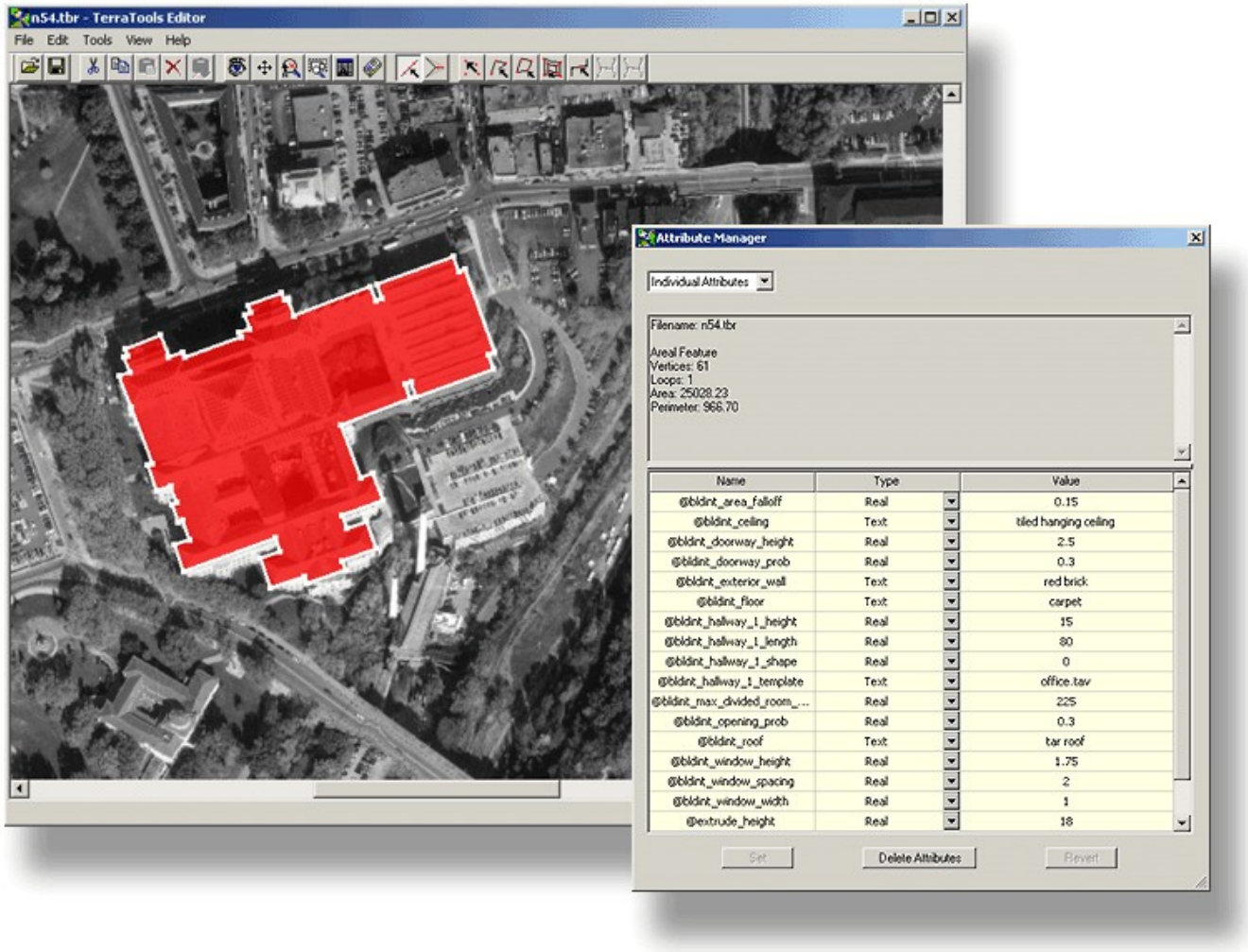

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Building Interior Attribution

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Name	Type	Value
@bldint_area_falloff	Real	0.15
@bldint_ceiling	Text	tiled hanging ceiling
@bldint_doorway_height	Real	2.5
@bldint_doorway_prob	Real	0.3
@bldint_exterior_wall	Text	red brick
@bldint_floor	Text	carpet
@bldint_hallway_1_height	Real	15
@bldint_hallway_1_length	Real	80
@bldint_hallway_1_shape	Real	0
@bldint_hallway_1_template	Text	office.tav
@bldint_max_divided_room_...	Real	225
@bldint_opening_prob	Real	0.3
@bldint_roof	Text	tar roof
@bldint_window_height	Real	1.75
@bldint_window_spacing	Real	2
@bldint_window_width	Real	1
@extrude_height	Real	18

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Random Building Blueprint Creation

- **Footprints are automatically divided into a network of rooms**
- **Exterior walls with windows and doors linking to outside are automatically generated as well**
- **Automatic interior model placement to populate rooms with “furniture”**
- **Utilities, such as plumbing and electric, can be automatically generated as well**

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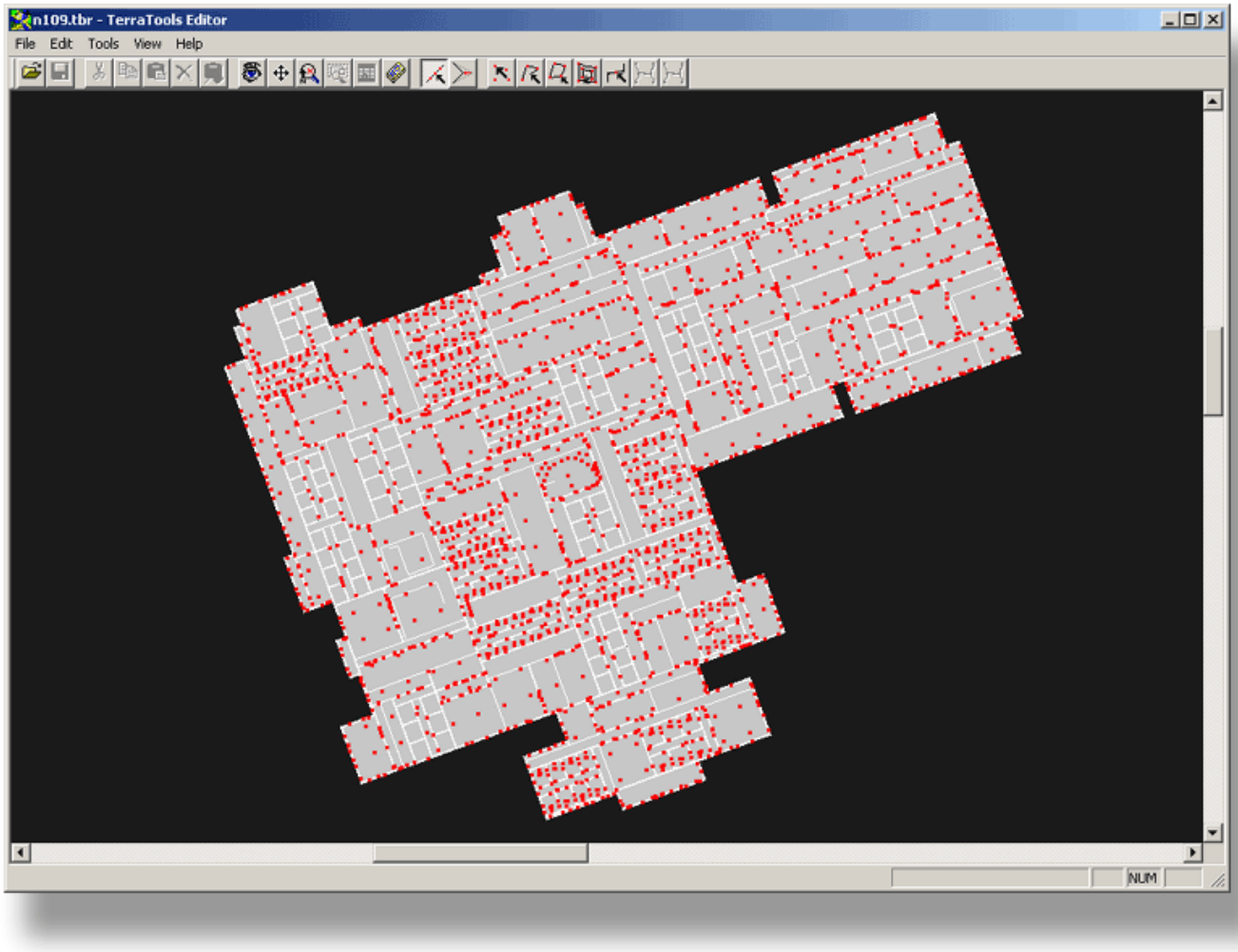
Random Building Blueprint Creation



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Editing Interior Building Blueprint

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- **Once random interior has been generated, it can be edited:**
  - Room boundaries can be changed
  - Interior models can be added/removed/manipulated
  - Layout can be adjusted to user preference

- **Editors/Viewers are provided within TerraTools to easily manipulate room interiors**

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Editing Interior Building Blueprint

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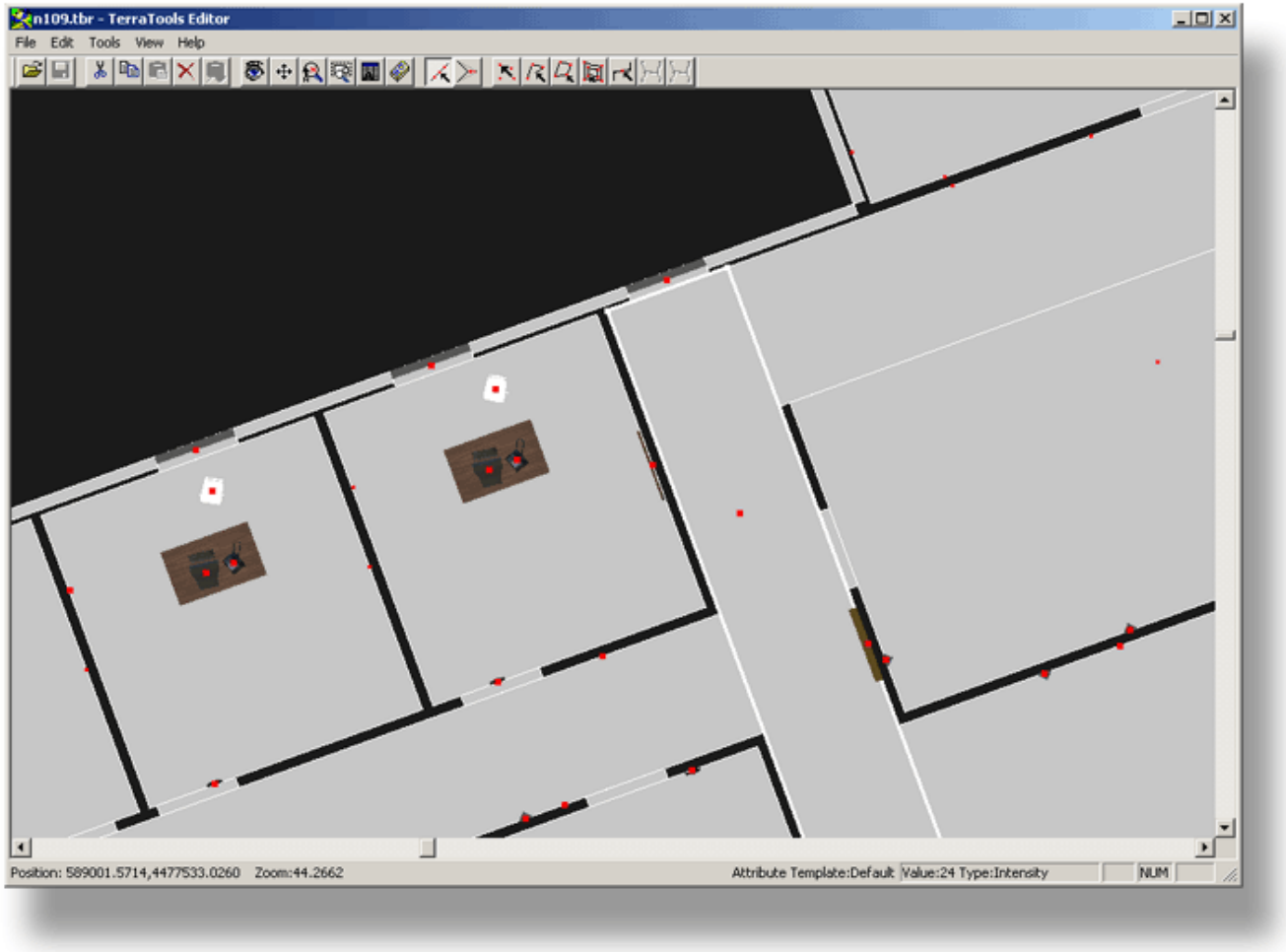

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Extrude Buildings from Blueprint

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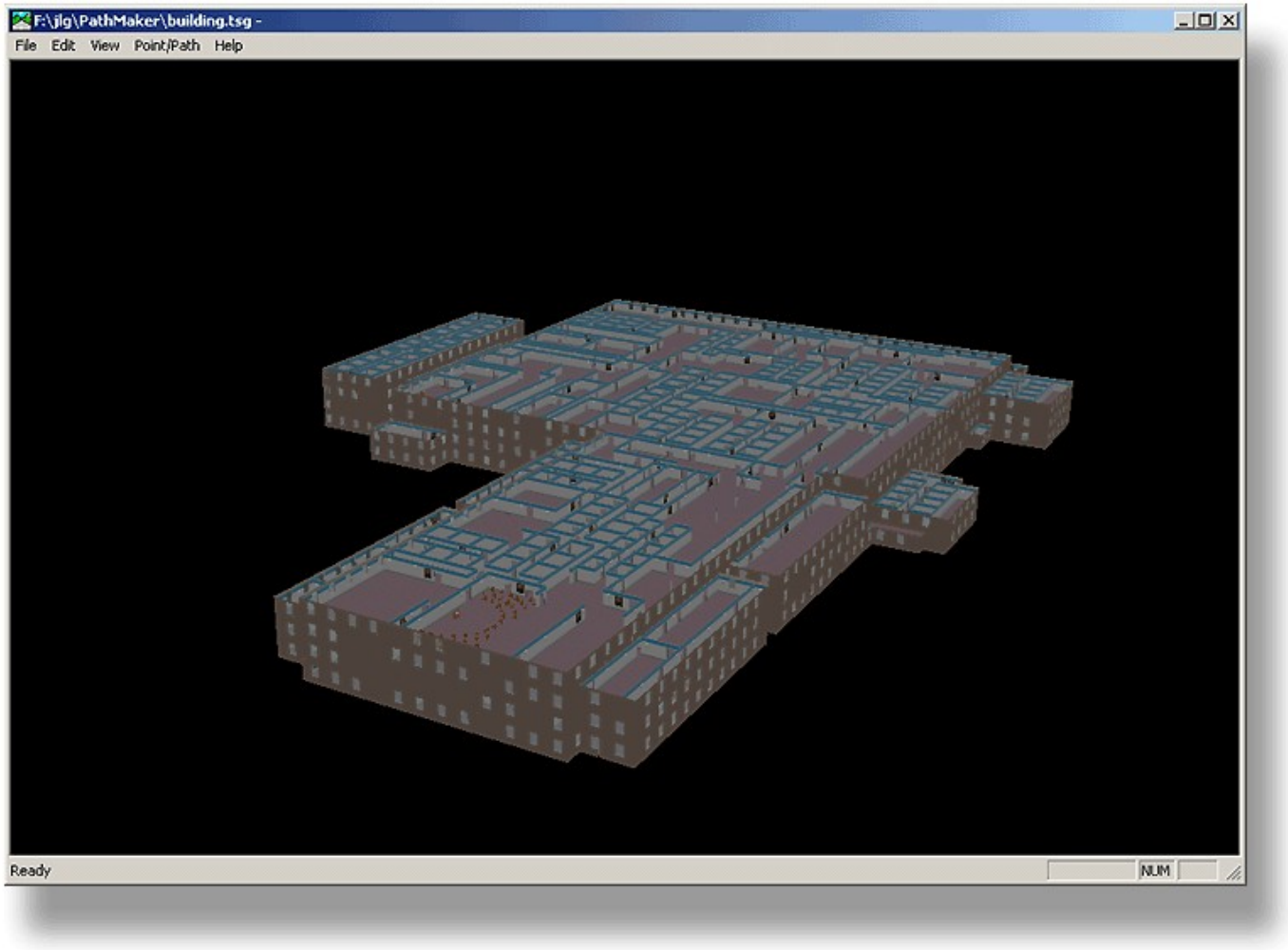
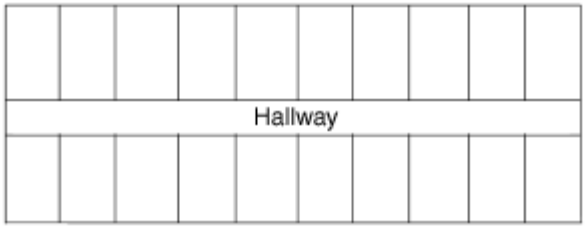
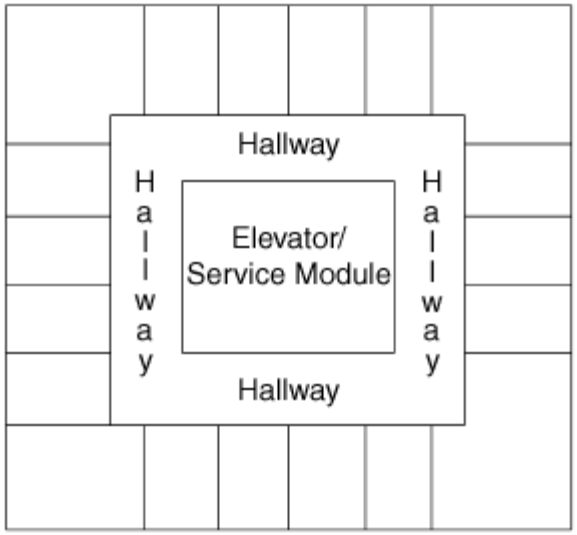


Simple UTZ Generic Building Interiors

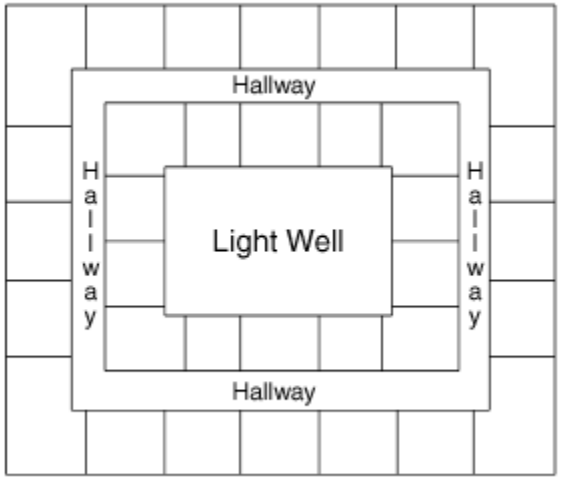


Linear hallway layout

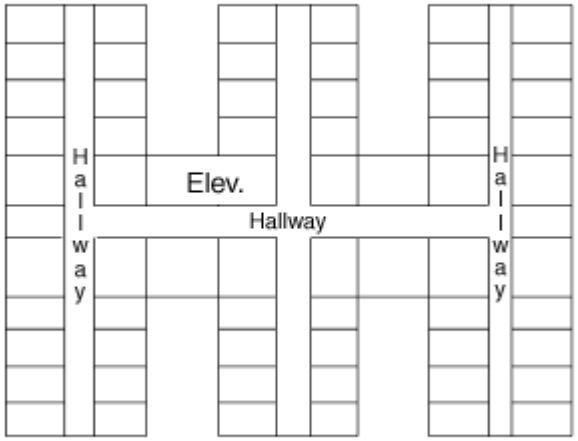


Central circulating hallway layout

Complex UTZ Building Interior Templates



Central light well layout



Building wing layout

Automatic **Geospecific** Building Interiors

- **Test case OneSAF IDE building**
  - First step is construction of interior structure
    - Use existing CAD data, minimal manual editing
    - Use geospecific exterior and interior textures
    - Automatic rooms, doors, and windows
  - Demonstrate IDE building replacement in CFTDC database
    - Ease of integration since database is constructed from GIS source
    - No manual modeling or positioning
    - Alternatives easily handled (e.g., geotypical vs. geospecific)
  - Ongoing research
    - Generation of stairwells, stairs, transitions between floors
    - Improve automation from CAD to room templates, still manual
    - More fully automate cross level positioning

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Compilation of CFTDC Source Vector Data

SOCETSET Display of Captured Features

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Compilation of CFTDC Source Vector Data

TerraTools ® Display of Data Layers

MOUT FACT Project Implementation Meeting, May 14-15

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CFTDC Visual Database

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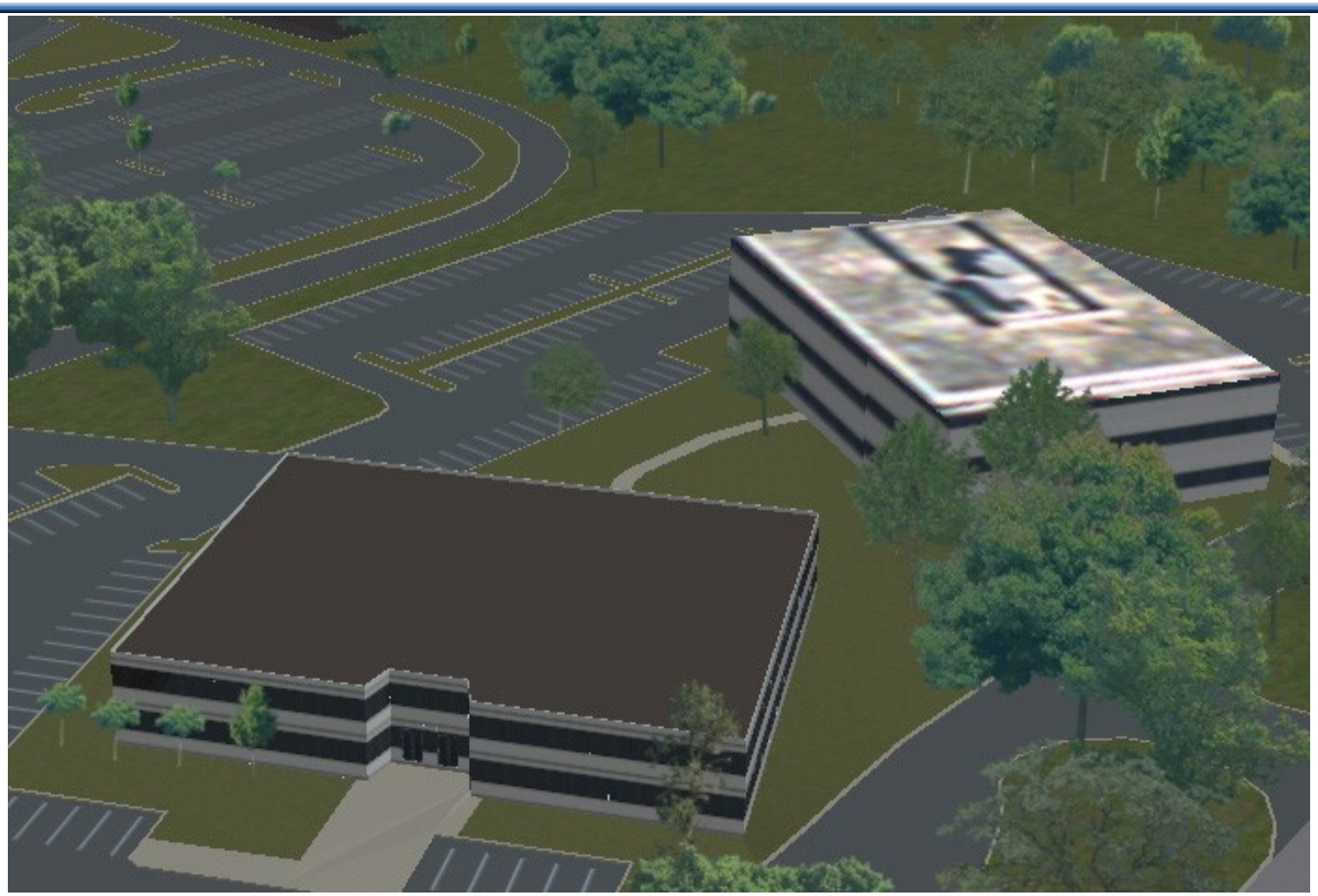

IDE Building

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Raw AutoCAD Data

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Initial CAD Data Source

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Complete Translation to Templates

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Completed “Smart CAD” Interior

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Room Templates with Hallways

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Interior “Smart CAD” Close Up

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Room Templates and Hallways

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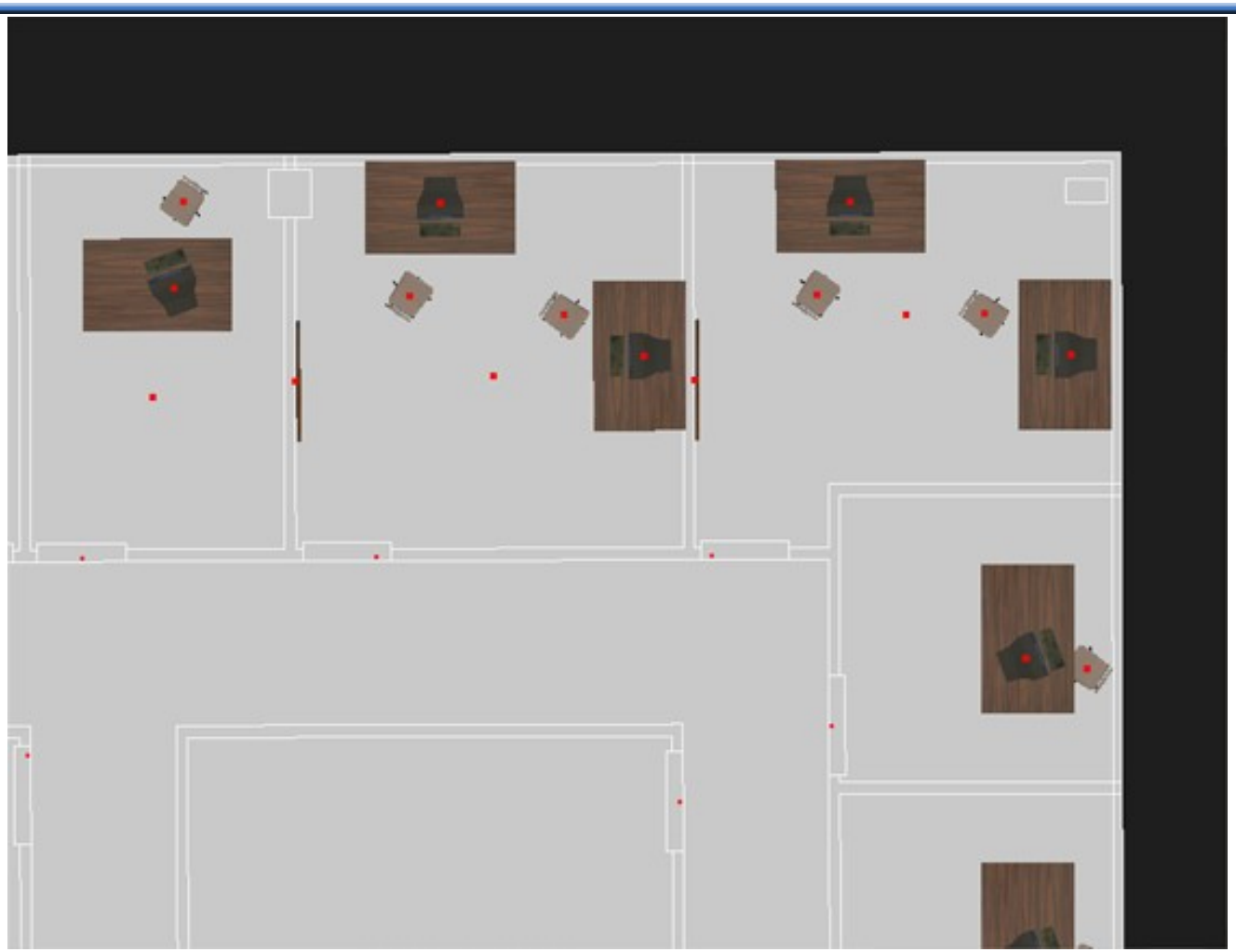

Interior “Smart CAD” Close Up

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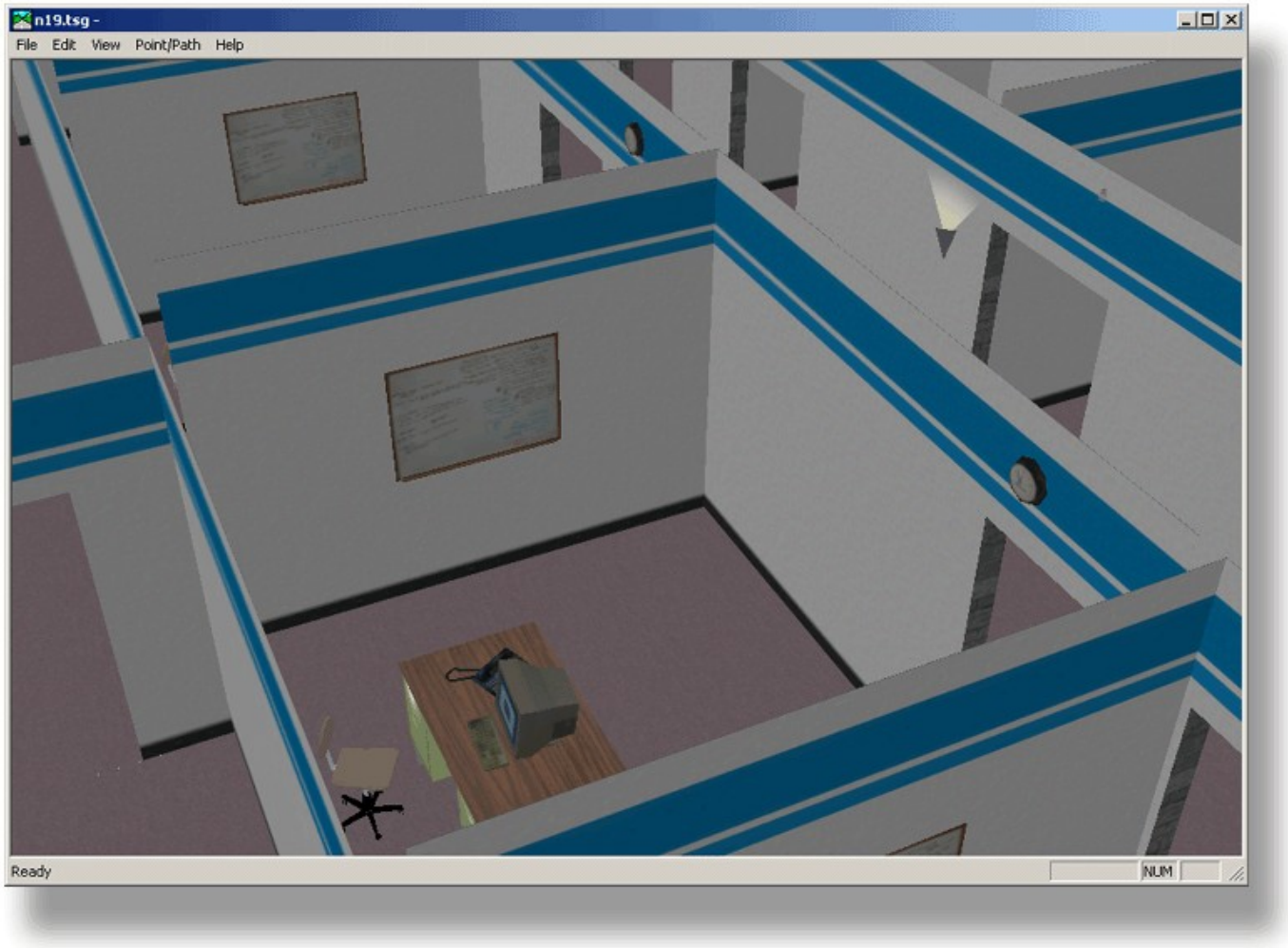
Room Templates



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IDE Building Interior

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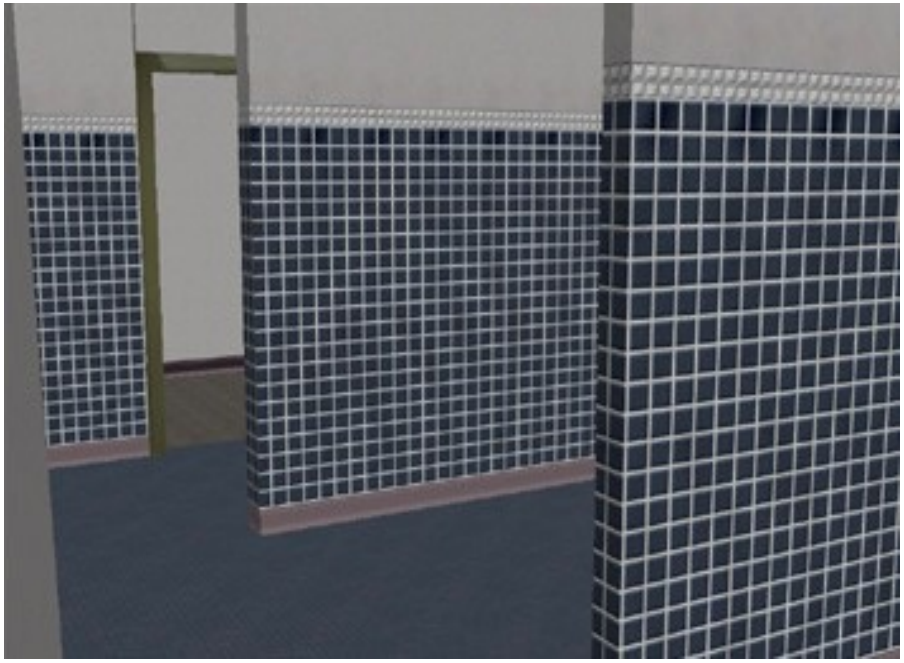
IDE Back Door



IDE Restroom

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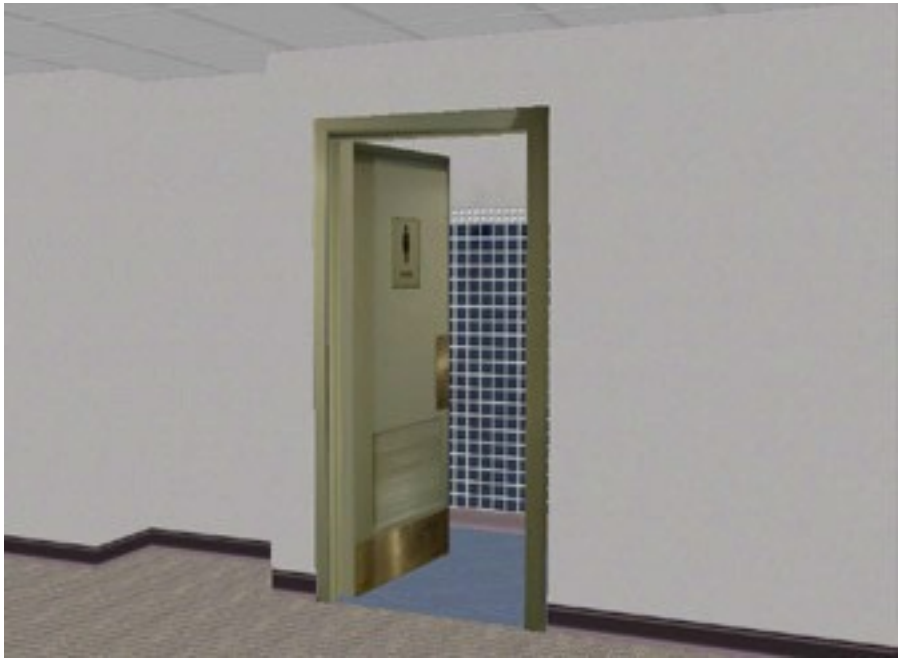
IDE Building Interior

IDE Entrance



Women's Restroom

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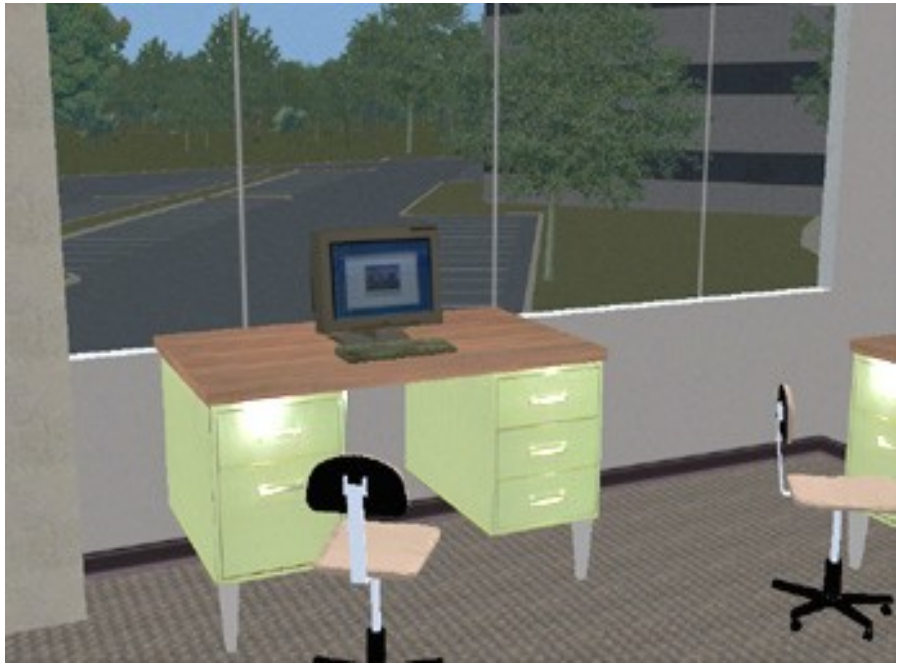
IDE Building Interior

First Floor Office



Second Floor Office

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Geospecific vs. Geotypical Appearance

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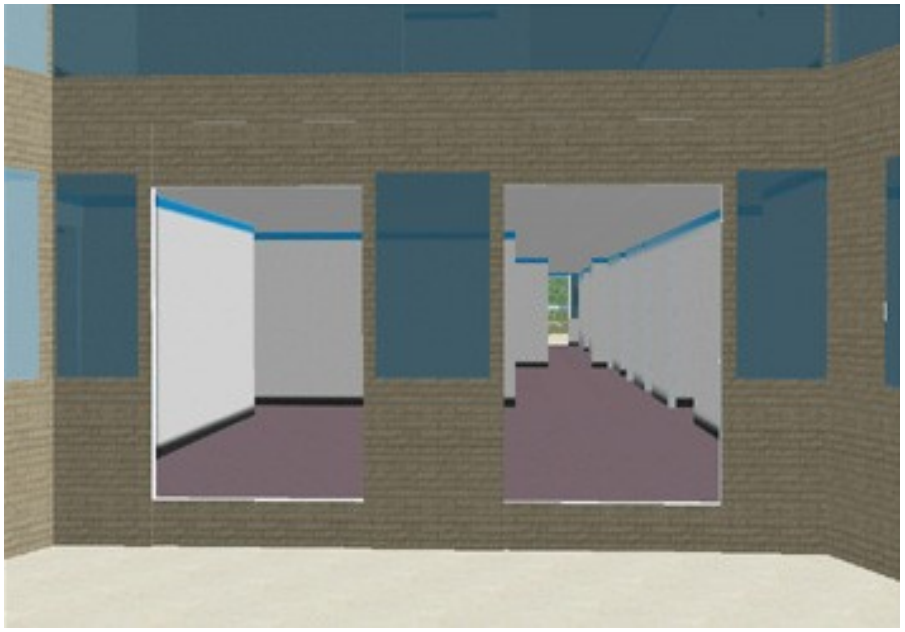
Geospecific



Geotypical

IDE Front Entrance

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Geospecific vs. Geotypical Appearance

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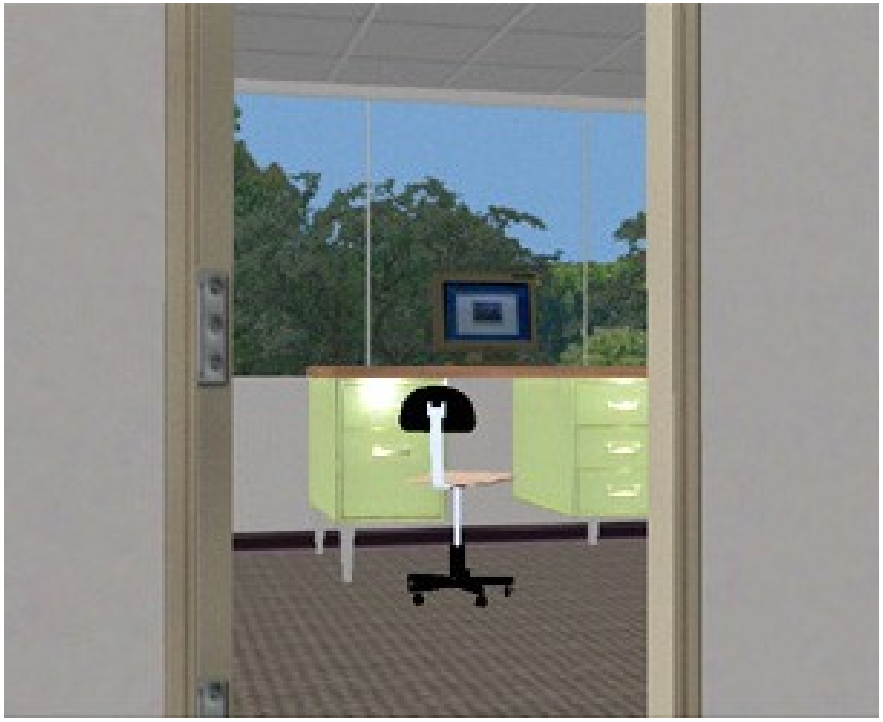
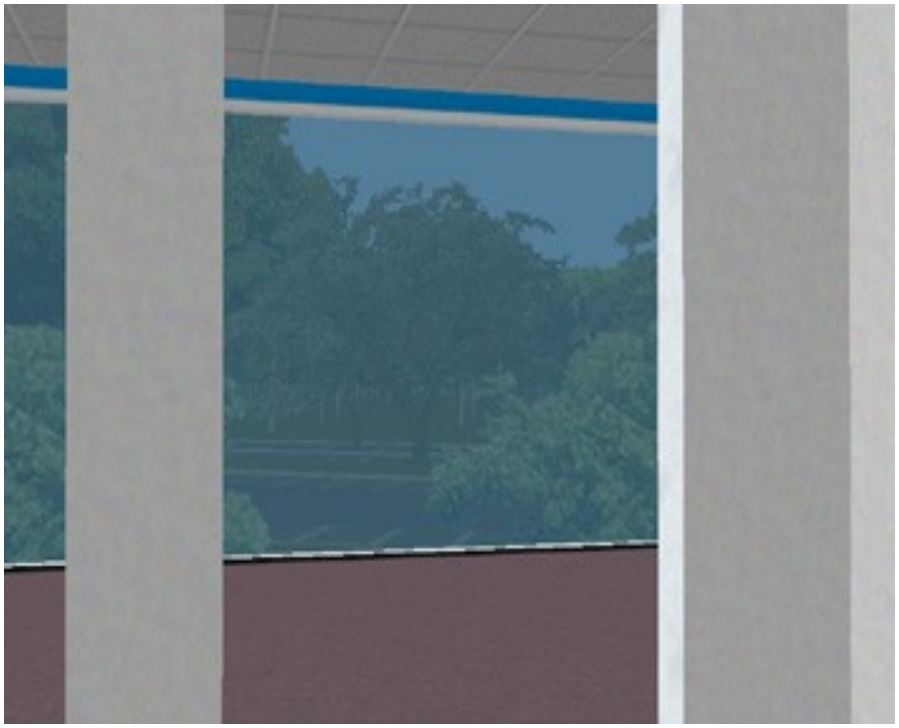


Geospecific



Geotypical

IDE Building Offices

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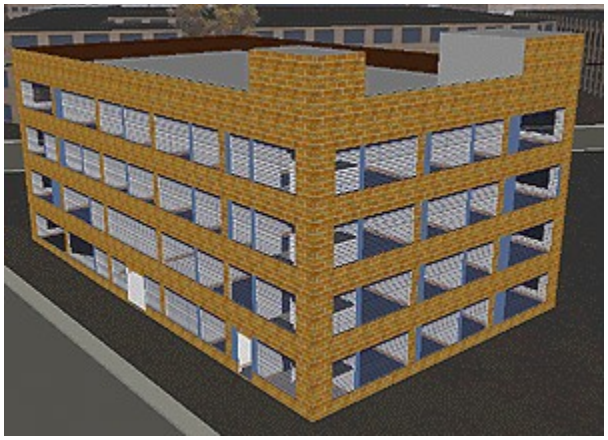
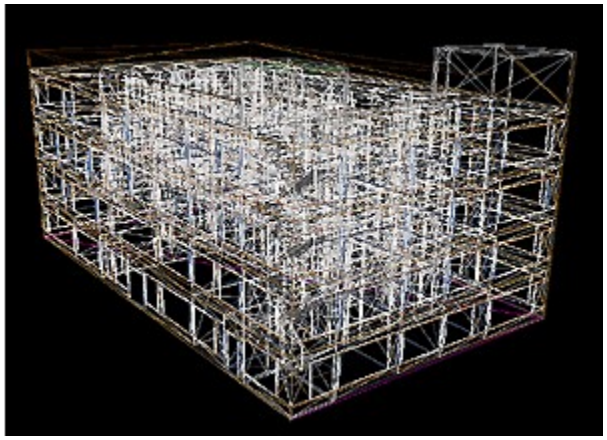
Toward Complex 3D Building Generation

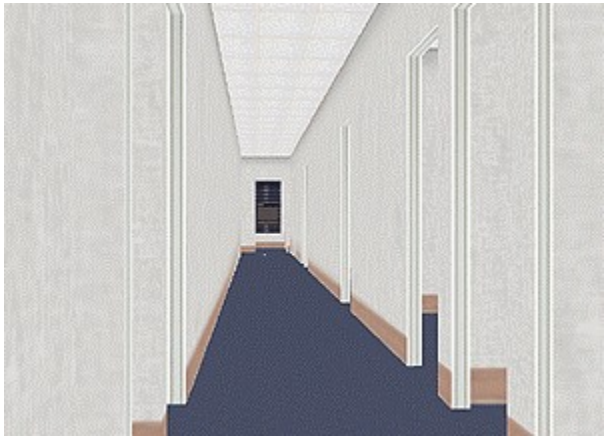


Multi-story office building



Geometry of building model

Exit stairwell, doorway, and window



Interior hallway with office entrances

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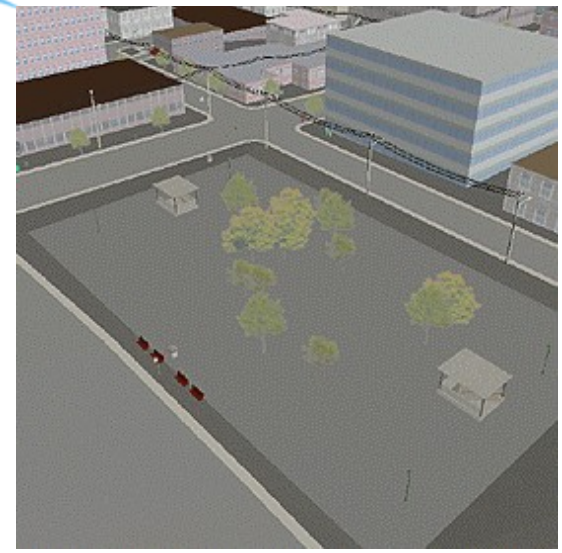
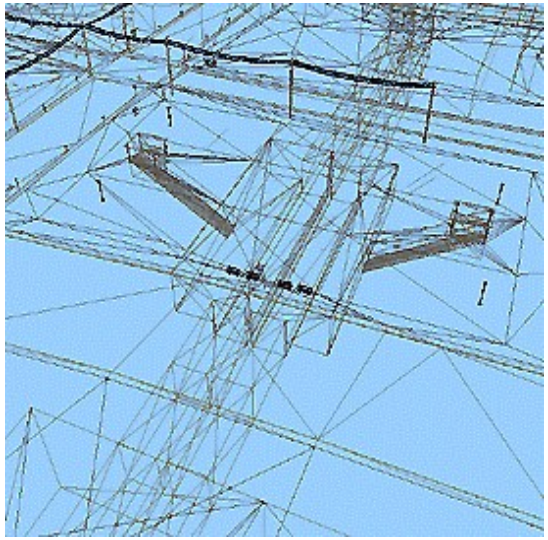
Underground Structures

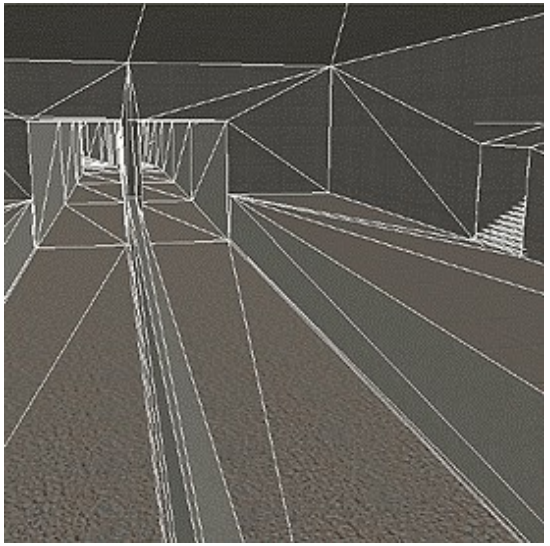


A subway stop, above ground

One subway entrance stairwell



Polygonal structure of the integrated subway station



Polygonal structure of the subway platform

Generated from Template Descriptions

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MOUT FACT Project 3 Technical Outcomes

- **Develop refined rapid MOUT generation for OneSAF and other programs**
- **Advance state-of-the-art in automated building interior generation tailored to OneSAF OOS and Combat XXI requirements**
- **Add to current WARSIM/OneSAF DBGS process flow MOUT output redistributable as SEDRIS (STF) for program developer use**
- **Export geometry to OneSAF Urban Environment Representation**
  - **Next generation Multi-Elevation Surfaces (MES)**
- **Demonstrate use of AMSAA UTZ formalism and demonstrate utility as formal data source for geotypical large area urban generation**

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MOUT FACT Project 3 Technical Outcomes

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- **Use ERDC-WES Worldwide Construction Practices database in conjunction with UTZ to produce UHR urban environments grounded in formal models for appearance, construction properties, and geospatial organization**

- **Deliver multiple sample databases to OneSAF Environmental PM for use, evaluation and redistribution**

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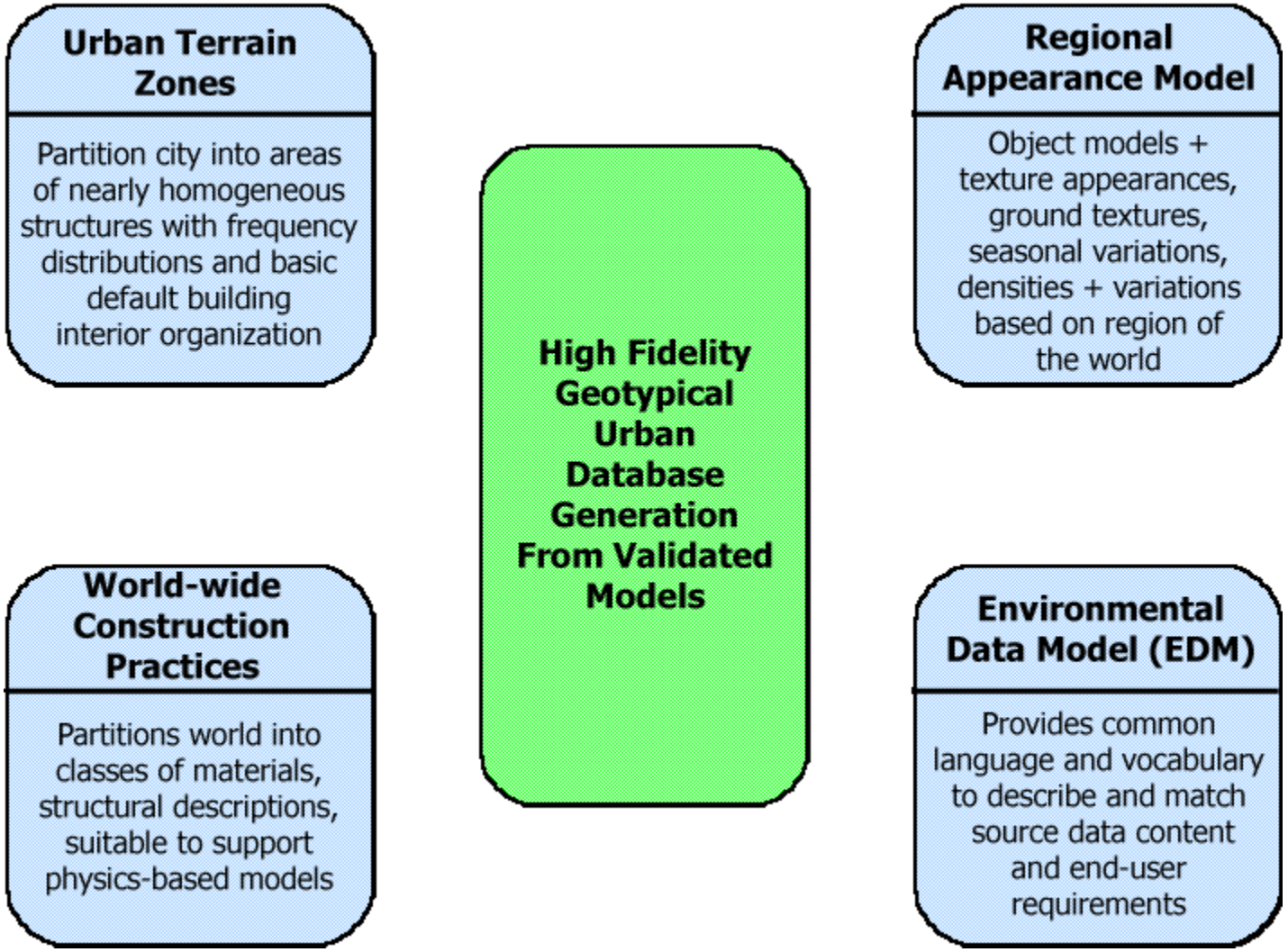
Automated Geotypical Urban Database Generation


Urban Terrain Zones
Partition city into areas of nearly homogeneous structures with frequency distributions and basic default building interior organization
Regional Appearance Model
Object models + texture appearances, ground textures, seasonal variations, densities + variations based on region of the world
High Fidelity Geotypical Urban Database Generation From Validated Models
World-wide Construction Practices
Partitions world into classes of materials, structural descriptions, suitable to support physics-based models
Environmental Data Model (EDM)
Provides common language and vocabulary to describe and match source data content and end-user requirements

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Abbreviations

- **UTZ: Urban Terrain Zone**
  - **formal characterization of urban geospatial organization**
    - **pioneered by AMSAA (Fordyce, Ellefsen)**

- **MES: Multi-elevation Surfaces**
  - **description of topology and semantics of building interiors**
  - **required for reasoning by computer generated forces**

- **CAD: Computer Aided Design**
  - **generic term for non-cartographic description of man-made structures, generally more complex than simulation requires**

- **UHR: Ultra High Resolution**
  - **the highest resolution required for individual combatants**